Technical Report Documentation Page

1. REPORT No.

FHWA/CA/TL-80/06

2. GOVERNMENT ACCESSION No.

3. RECIPIENT'S CATALOG No.

4. TITLE AND SUBTITLE

Transportation Systems And Regional Air Quality
Photochemical Modeling Of Sacramento, California Region

5. REPORT DATE

February 1980

6. PERFORMING ORGANIZATION

7. AUTHOR(S)

Bennett T. Squires, Roy W. Bushey, Earl C. Shirley

8. PERFORMING ORGANIZATION REPORT No.

19701-603116

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Office of Transportation Laboratory
California Department of Transportation
Sacramento, California 95819

10. WORK UNIT No.

11. CONTRACT OR GRANT No.

A-8-27

12. SPONSORING AGENCY NAME AND ADDRESS

California Department of Transportation
Sacramento, California 95807

13. TYPE OF REPORT & PERIOD COVERED

Interim April 1976 to October 1979

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This work was accomplished in cooperation with the United States Department of Transportation.

16. ABSTRACT

In cooperation with the California Air Resources Board and the Sacramento Regional Area Planning Commission, regional modeling was performed simulating a high ozone day in Sacramento, California. The study area was selected to include populated sections of Sacramento. An air pollution emission inventory was taken for the study area. Field gathering of meteorologic and aerometric data was done in the summer of 1976. Verification of two models, the SAI 15-step chemistry and the SMOG models was attempted. A verification was not effected with the SAI model, but the SMOG model seemed to verify. Problems involved with the use of each model are discussed as are the unique properties of the models. The SMOG model results depended significantly more on initial conditions than on emission levels.

17. KEYWORDS

Air pollution control strategies, ozone, photochemical modeling, emissions inventory, model validation

18. No. OF PAGES:

171

19. DRI WEBSITE LINK

http://www.dot.ca.gov/hq/research/researchreports/1978-1980/80-06.pdf

20. FILE NAME

80-06.pdf

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

February 1980

FHWA No. A-8-27
TL No. 603116

TRANSPORTATION SYSTEMS AND REGIONAL AIR QUALITY

PHOTOCHEMICAL MODELING OF SACRAMENTO, CALIFORNIA REGION

Study Made by .... Enviro-Chemical Branch

Under the Supervision of .... Earl C. Shirley, P.E.
and Roy W. Bushey, P.E.

Principal Investigator .... Bennett T. Squires, P.E.

Report Prepared by .... Bennett T. Squires, P.E.

APPROVED BY

Neal Andersen

NEAL ANDERSEN
Chief, Office of Transportation Laboratory

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.
FHWA/CA/TL-80/06

2. GOVERNMENT ACCESSION NO.

3. RECIPIENT'S CATALOG NO.

4. TITLE AND SUBTITLE
TRANSPORTATION SYSTEMS AND REGIONAL AIR QUALITY -- PHOTOCHEMICAL MODELING OF SACRAMENTO, CALIFORNIA REGION

5. REPORT DATE
February 1980

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Bennett T. Squires, Roy W. Bushey, Earl C. Shirley

8. PERFORMING ORGANIZATION REPORT NO.
19701-603116

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Office of Transportation Laboratory
California Department of Transportation
Sacramento, California 95819

10. WORK UNIT NO

11. CONTRACT OR GRANT NO.
A-8-27

12. SPONSORING AGENCY NAME AND ADDRESS
California Department of Transportation
Sacramento, California 95807

13. TYPE OF REPORT & PERIOD COVERED
Interim April 1976 to October 1979

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
This work was accomplished in cooperation with the United States Department of Transportation.

16. ABSTRACT

In cooperation with the California Air Resources Board and the Sacramento Regional Area Planning Commission, regional modeling was performed simulating a high ozone day in Sacramento, California. The study area was selected to include populated sections of Sacramento. An air pollution emission inventory was taken for the study area. Field gathering of meteorologic and aerometric data was done in the summer of 1976. Verification of two models, the SAI 15-step chemistry and the SMOG models was attempted. A verification was not effected with the SAI model, but the SMOG model seemed to verify. Problems involved with the use of each model are discussed as are the unique properties of the models. The SMOG model results depended significantly more on initial conditions than on emission levels.

17. KEY WORDS
Air pollution control strategies, ozone, photochemical modeling, emissions inventory, model validation.

18. DISTRIBUTION STATEMENT
No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. SECURITY CLASSIF. (OF THIS REPORT)
Unclassified

20. SECURITY CLASSIF. (OF THIS PAGE)
Unclassified

21. NO. OF PAGES
171

22. PRICE

DS-TL-1242 (Rev.6/76)

CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quanity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic yards (yd^3)	3.785 .02832 .7646	litres (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour(mph) feet per second(fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity(G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^2)
Force	pounds (lbs) kips (1000 lbs)	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds(ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds(ft-lbs) foot-pounds(ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

ACKNOWLEDGEMENTS

The success of this project is due to the cooperation of personnel from many agencies.

At the Transportation Laboratory, credit is given to Messrs. K. Pinkerman, O. Box and D. Poelstra (deceased) for establishing and operating the field monitoring installations; Mr. J. Racin for leading the modeling effort on the SAI 15-step chemistry model; and Messrs. R. Duncan, D. Wood and G. Vidwan and Miss M. Johnson for editing and organizing various data.

At the Caltrans District 03 office in Marysville, thanks to Messrs. N. Baker, J. Antonetti and B. Rogers for their help in all aspects of the field monitoring effort, and Messrs. B. Brockett and C. Olsen for their assistance in the traffic related emissions data gathering.

At the Caltrans Department of Transportation Planning, the help of Mr. L. Seitz in the effort to accumulate mobile emissions data is acknowledged.

The patient help of Messrs. R. Baishiki and J. Falkinbury, and Mrs. S. Doughty of the Caltrans Office of Computer Systems was invaluable.

The project would not have been possible without considerable assistance from personnel of the California Air Resources Board (ARB) staff. From the ARB's Modeling Air Quality Unit supervised by Mr. A. Ranzieri, the efforts of Messrs. P. Allen and T. Woody, and Drs. J. Tilden and P. Amar are gratefully acknowledged. Messrs. M. Redemer and E. Yotter, also of the ARB staff, are acknowledged for their help in accumulating the emissions inventory.

The Sacramento Regional Area Planning Commission, Mr. J. Barnes, Executive Director, furnished general direction and funding for the emissions aspects of the project; and staff members Messrs. R. Knight, P. Bisbiglia, and P. McAuliffe were especially helpful in completion of the project.

The Sacramento County Air Pollution Control District, Mr. R. Cofer, Air Pollution Control Officer, and the Placer County Air Pollution Control District, Mr. K. Selover, Air Pollution Control Officer, furnished the stationary emissions inventory for the study. To Messrs. B. Nixon, E. Skelton and S. Kalvelage, of the Sacramento APCD staff, special thanks for their efforts.

Mr. D. Martin of the Sacramento Municipal Utility District contributed air quality data from the Rancho Seco site.

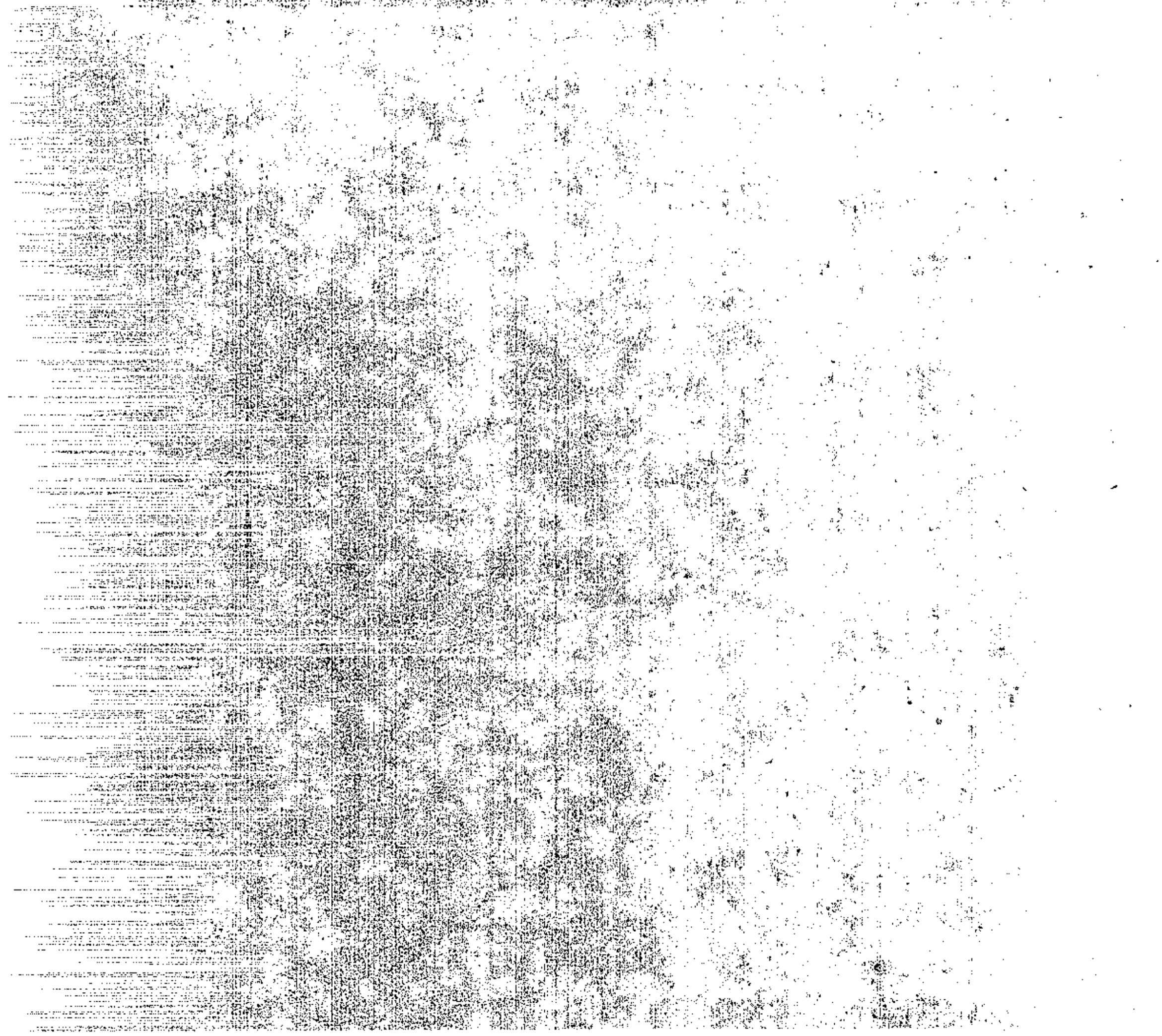
Mr. Ken Jones of the Federal Highway Administration Office of Research, the principal funding organization, provided valuable and patient guidance throughout the life of the project.

TABLE OF CONTENTS

TABLE OF CONTENTS (con't.)

LIST OF FIGURES

LIST OF FIGURES (con't.)



LIST OF TABLES

INTRODUCTION

The research project entitled "Transportation Systems and Regional Air Quality" was initiated in 1974. Objectives of the most recent research are to generate verified regional air quality computer models for the Sacramento, Fresno, Bakersfield, and San Diego areas of California with emphasis placed on models with atmospheric chemistry algorithms for the generation of ozone. This is a report on modeling activities in the Sacramento area.

This report is the sixth in the series published under this research project. The reports titled "Transportation Systems and Regional Air Quality - An Approach and Computer Program for Wind Flow Field Analysis", "Transportation Systems and Regional Air Quality - A DIFKIN Sensitivity Analysis", "Evaluation of a Modified APRAC-1A Carbon Monoxide Diffusion Model for the Sacramento Region", "A Consistent Scheme for Estimating Diffusivities to be Used in Air Quality Models" and "Design of an Air Quality Monitoring Trailer for Regional Air Quality Assessment" have been completed. The seventh and final report for this project will cover the Fresno regional modeling activities.

Regional air quality models are being developed to aid officials in environmental planning. Those planners and engineers charged with complying with the Clean Air Act can then evaluate proposed transportation plans, zoning restrictions, and energy saving ideas on the verified models in terms of changes in local air quality.

Federal law mandates the development of a regional Air Quality Maintenance Plan (AQMP) to provide a "roadmap" for local jurisdictions to attain the National Ambient Air Quality Standards (NAAQS). The plan necessarily involves control of stationary and mobile source pollutant emissions.

The modeling output is used by the planners in selecting the transportation control strategies to be incorporated in the AQMP, and in providing backup evidence when the proposed strategies are standing for approval. It is anticipated that among the applications of this work will be: 1) consideration of the environmental effect of transportation systems, 2) location of optimum sites for those transportation systems determined to be environmentally acceptable, 3) consideration of impact of land use and population growth on air quality, 4) optimal location of major industrial pollution sources found to be necessary and/or acceptable, and 5) guidance for agencies with insufficient resources to perform expensive air quality analyses.

This report treats, in approximate chronological order, the steps necessary in preparing data for the modeling work. This work typically starts with "field work" which is largely gathering air quality and meteorological data followed by processing of these data into acceptable form for the modeling programs. Methodology for accumulating pollutant emission inventories, both mobile and stationary, is the subject of a section, as is the selection of candidate days for modeling. The verification process is described and potential use of modeling output is discussed.

Finally, the Sacramento modeling project is discussed with emphasis on the use of modeling by the Sacramento Regional

Area Planning Commission (SRAPC), and recommendations for future work are made.

CONCLUSIONS

1. Regional photochemical modeling is too complex to be performed routinely by transportation planners or engineers. Specialized modelers who are familiar with modeling theory and computer procedures must supervise the work or be available for consultation on a regular basis. It is also helpful to have access to persons with experience in siting air quality monitoring stations and interpreting aerometric and meteorologic data.

2. The Systems Applications, Inc. (SAI) 25x25 Airshed Model with 15-Step Chemistry could not be verified for the candidate day June 28, 1976, in the Sacramento region.

3. The California Air Resources Board (ARB) SMOG model can generally reproduce the measured ozone concentrations within ± 25 percent of the measured values. The correlation coefficients of the measured with the modeled ozone concentrations are excellent.

4. SMOG tends to predict highest ozone concentrations downwind of the maximum precursor emissions of NO_x and hydrocarbons.

5. SMOG tends to predict the temporal and spatial patterns of ozone, NO_2 and NO consistent with measurements.

6. Based on single day dawn to dusk simulation runs, SMOG appears to be sensitive to the specification of initial and boundary conditions for hydrocarbons and NO_x and insensitive to significant changes in emission rates. At its present level of development, the model can be expected to predict daily exceedances of the State and National Ambient Air Quality Standards (NAAQS) but should not be expected to evaluate effects of emission control strategies.

7. Based on SMOG simulation runs for the Sacramento region, emission controls on a mesoscale or microscale basis would have little effect on reducing ozone levels on the first day of their implementation. For this reason, emergency controls in episodic situations would be ineffective on the first day or two.

8. In planning a modeling program, one of the last decisions should be the selection of the model to be used. The development of photochemical models is dynamic and the investigator should expect that new or improved models will be identified during the execution of the project. Maximum flexibility during preparation for the computer work should be maintained in order that the latest modeling improvements can be incorporated.

9. Although consistent transport of pollutants into the Sacramento region probably occurs, conclusive evidence of this phenomenon was not shown by this investigation.

RECOMMENDATIONS FOR ADDITION WORK

1. Evaluate the SMOG model for multi-day simulations to allow a more realistic evaluation of emission control strategies. Initial concentrations become less important for longer simulations.

2. If the multi-day simulations show sensitivity to emissions, future control strategies for transportation related emissions in the Sacramento area should be evaluated for ozone impact using the SMOG model. Concentrations describing initial and boundary conditions must be changed to reflect changes in emission patterns from the base year.

3. Perform an analysis to establish the relative sensitivity of the SMOG model to various initial and boundary conditions for NO_x and hydrocarbons. These are the pollutants that transportation related sources contribute toward ozone generation, and such an analysis would be most useful in choosing future control strategies.

4. Evaluate the SMOG model for different types of meteorological conditions.

5. Support the continued development and evaluation of new photochemical models. As an example, the California Institute of Technology has a regional ozone model in an advanced state of development. Development of such new models is most rational when it is based on user evaluation of deficiencies in existing models.

AGENCY RESPONSIBILITY

The air quality regional modeling for the Sacramento area was a joint effort of several agencies. These agencies are the Modeling Air Quality Unit of the ARB, the ARB Planning Division, the California Transportation Laboratory, the California Department of Transportation Planning, the California Department of Transportation District 03 office in Marysville, the Placer County Air Pollution Control District, the Sacramento County Air Pollution Control District and the Sacramento Regional Area Planning Commission.

Overall direction was provided by the Sacramento Regional Area Planning Commission (SRAPC) and funding was provided by SRAPC, Caltrans District 03, and the Caltrans Laboratory. The air quality and meteorologic data base for model verification was gathered by Caltrans Laboratory and Caltrans District 03. The latter two agencies participated in the field work, and personnel of the State Department of Health calibrated the monitoring instruments. Data reduction was provided by personnel of the California Transportation Laboratory. The stationary emissions inventory was made by personnel of the Sacramento County Air Pollution Control District (APCD) and the Placer County APCD. Raw data for the mobile emissions inventory was provided by Caltrans District 03 and the Caltrans Department of Transportation Planning. The ARB Planning Division provided computer programming for automation of the mobile emissions data. Data input and execution of the SMOG model were performed by personnel of the ARB's Modeling Air Quality Unit (MAQU) while data input and execution of the SAI model were done by personnel of the California Transportation Laboratory.

A series of reports (enumerated in Appendix A) concerning the air quality modeling in relation to the AQMP program for the Sacramento area were published by SRAPC.

STUDY AREA

A gridded study area is ordinarily used for Eulerian (each grid square's air quality studied individually) and LaGrangian (the quality of a parcel of air is studied as it advects across a number of grid squares) models. To accommodate the SAI and SMOG regional photochemical models which are Eulerian models, the Sacramento area was divided into 625 squares, 25 squares per side. The actual control was the SAI model, the Caltrans version of which cannot handle an area with more than 25 grid cells per side. The size of each grid square is 2 km x 2 km; and the point of cartesian origin, that is, the southwest corner grid square (1, 1), has the Universal Transverse Mercator (UTM) designation of 616,000 meters east and 4,245,000 meters north.* The grid square numbering increases toward the east and toward the north, thus the location of any feature within the grid can be represented by the coordinates of the grid square in which it resides.

The limits of the grid were chosen, in general, to include the metropolitan Sacramento area and, in particular, to include the Rancho Seco nuclear generating plant, the Port of Sacramento, all four major airports, the City of Roseville, and the suburban northeast area. The location of the Sacramento gridded area is shown in Figure 1. The gridded area is depicted in Figure 2.

*The origin was placed at even UTM kilometers for convenience in assigning emissions to each grid cell. Caltrans and the ARB tally mobile and stationary emissions, respectively, by square kilometers of earth surface as gridded by UTM coordinates. Since each grid cell for the study project was four square kilometers in area, the emissions assignment was made by summing the four appropriate square kilometer data.

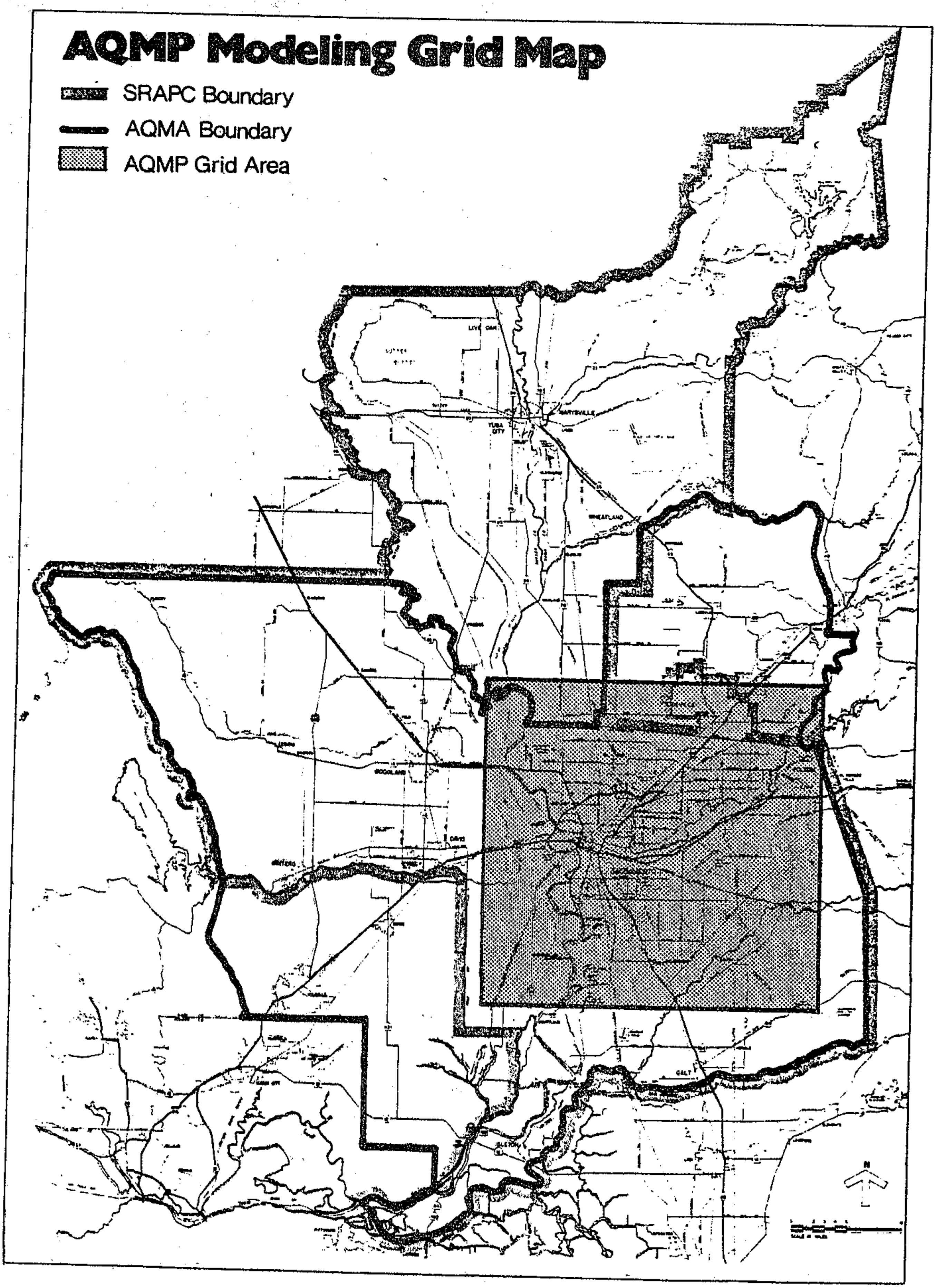

AQMP Modeling Grid Map
SRAPC Boundary
AQMA Boundary
AQMP Grid Area

FIGURE 1

SACRAMENTO MODELING REGION

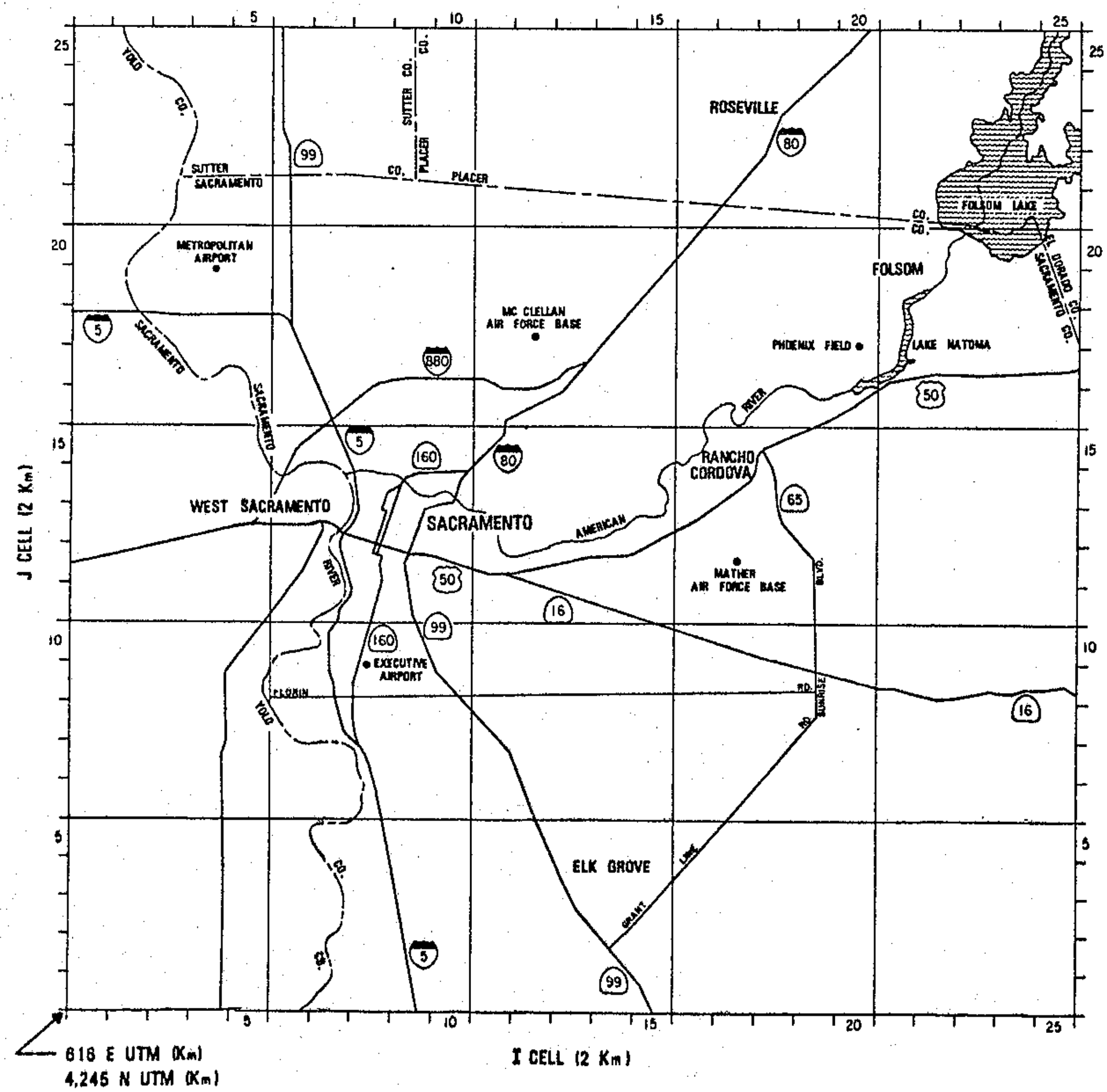


FIGURE 2

The concept of a regional grid is especially versatile. There are 625 distinct areas in which one can total up emissions and give those totals to the computer program, and there are the same 625 distinct areas in which the computer can compute pollutant concentrations. The 100 surface grid squares that border the area are ordinarily used to assign concentrations to air being advected into the area. Any control strategy chosen by planners to alleviate air quality problems can be assigned to a grid square(s), and the computer model will attempt to evaluate the significance of the strategy in that particular location. Throughout this report locations will be referred to by their grid square.

GEOGRAPHY

The Sacramento Valley is a well defined climatic region bounded on three sides by topographic barriers. They are the Coast Range on the west, the Cascade Range on the north and the Sierra Nevada Mountains on the east. The southern boundary is not marked by any distinguishing topographic feature. It does, however, lie close to the Delta lowlands and the Carquinez Strait. The Carquinez Strait is the major low-level gap in the Coast Range through which the summertime marine air intrusions enter the valley. The configuration of the valley and the surrounding mountain ranges dominate the wind flow patterns throughout the year and act to confine pollution within the valley under stagnant meteorological conditions.

The high pressure cell that typically rests in the eastern Pacific Ocean off the California coast the entire summer results in extensive sunshine and a general absence of migratory storms. The basin-shaped central valley in the summer is usually the site of subsidence inversions in which warm air takes on additional heat by compression as it descends. Periodic relief from the heat is provided when thermal convection from the hot surface of the earth creates inland low pressure which propagates wind flow toward the interior through the Carquinez Strait. These, the most prevalent summer winds in the Sacramento region, are from the southwest.

The Sacramento region has a flat topography. The populated area is surrounded by agriculture, and only along the eastern edge of the gridded study area does evidence of the Sierra foothills appear.

The lack of surface relief tends to encourage uniform wind flows and minimize the appearance of surface channels where wind speeds would be higher than those in the surrounding areas. The lack of surrounding mountains also minimizes the occurrence of drainage winds. The Sacramento area's relative geographic simplicity makes it quite desirable for air quality simulation modeling.

PHOTOCHEMICAL MODEL DESCRIPTION

Systems Applications, Incorporated (SAI) of San Rafael, California, is the developer of the SAI airshed air pollution simulation model (1). Appendix A, part 1, is a list of reports concerning the SAI airshed model. The SAI model is an Eulerian (grid) model. This means that conditions within a specified area in the study region (the so called grid square) are the basic consideration of the modeling process. For each minute of the analysis period, the air quality conditions within each grid square are updated using current pollutant level, meteorologic, and chemical reaction state information. For each full hour, all the grid squares are concatenated (linked together) to form a computer generated maplike layout. The calculations use a numerical solution of the atmospheric diffusion equation based on the method of fractional steps.

The chemistry uses the Hecht-Seinfeld (2) lumped reaction mechanism. Although horizontal diffusion is based on mass conservation and is explicit, the algorithm developed by Eschenroeder, et al, (3) is used for vertical diffusion with a very limited description of vertical air quality and meteorologic conditions accepted at input. Thus, little vertical resolution information is used by the program. This shortcoming is reflected in the output.

Although there are several more recent updates of the program providing flexibility in grid scale selection, and updated chemical mechanisms, the SAI airshed model program in Caltrans' custody specifies a 15-step chemistry and only 25 grid cells in the north-south and the east-west directions. For these reasons the Caltrans version now is considered out of date.

The Integrated Model for Plumes and Atmospherics in Complex Terrain (IMPACT) is also a grid model (4, 5) and input and output are generally similar to the SAI model. IMPACT solves the conservation of mass equation with a more detailed representation of wind and diffusion, especially in the vertical dimension, and uses significantly more sophisticated chemistry.

IMPACT is a product of an office of Science Applications, Inc., based in La Jolla, California. IMPACT was developed by Dr. Ralph Sklarew in Westlake Village, California. Dr. Sklarew now has his own firm (Form and Substance, Inc.) in Westlake Village. IMPACT has been revised, and is now in the custody of MAQU. IMPACT began as a point source model and has been expanded by Dr. Sklarew and MAQU personnel into a model with regional capabilities. MAQU has renamed it "Simulation Model for Ozone Generation" (SMOG). The SMOG model was used with success on the Sacramento project.

The SAI model is of the genre 1971-1973, and SMOG was developed during the period from 1976 to 1978. Thus, SMOG provides advanced features, the necessity of which has been determined by experience gained only by years of working with and evaluating simulation models. One of the aims of the research was to determine a regional photochemical model suited to analysis of the effects of transportation systems on the air quality of a basin. Although neither the SAI or SMOG models in their present state are capable of describing the mesoscale effect of the presence or absence of a transportation system, this report suggests the steps necessary to achieve such a capability.

STATIONARY EMISSIONS INVENTORY

Integrated point and area source stationary emissions were determined for each grid cell in the Sacramento modeling area. Personnel in the employ of the Sacramento County APCD and the Placer County APCD assigned appropriate pollutant emissions to each of the grid cells in their areas. Caltrans personnel made grid cell assignments of emissions for Sutter and Yolo Counties. Pollutants inventoried included carbon monoxide (CO), oxides of nitrogen (NO_x), total hydrocarbons (THC), oxides of sulfur (SO_x), and total suspended particulates (TSP).

The inventory data are based on the year 1976. Three high ozone days in that year (June 28, August 24, and August 27) were selected for computer modeling to verify the models' simulation capability.

Point source emissions were taken from permits on file with the APCDs while various methods were used to determine area source estimates. Non-anthropogenic emissions from area sources, such as vegetation, were not included in the emissions inventory. Detailed descriptions of the development of the area source emissions inventory are in a report by the Sacramento APCD (6) and a comprehensive overview of the emission inventory work and its relationship to the modeling study was reported by SRAPC (7).

A file of the stationary emissions was placed on magnetic tape to be accessed for the SMOG model.

THE SATS MODEL PROCESS

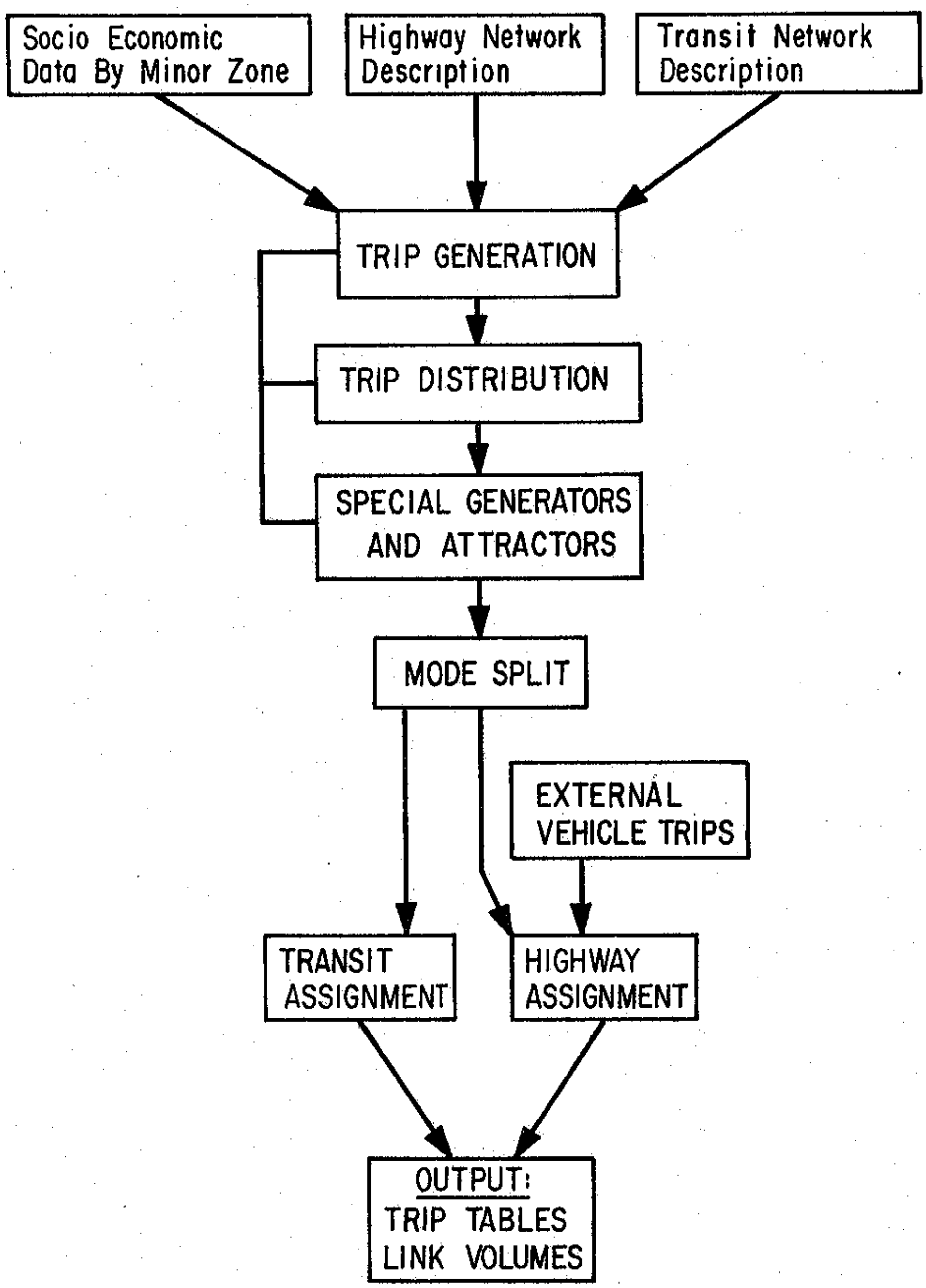


FIGURE 3

MOBILE EMISSIONS INVENTORY

For the purposes of this study, mobile emissions were taken to include only highway vehicles. Emissions from aircraft, rail sources, and ships entering the Port of Sacramento were included by grid square among the stationary emissions.

Emissions from highway vehicle sources were estimated using two models, the Sacramento Area Transportation Study (SATS) and the Direct Travel Impact Model (DTIM). The two models are used to complement each other and generate emissions from highway vehicle sources that are assigned to each of the 625 grid squares. The base year used was 1976, and the models were programmed to generate emissions for any year through 1995.

The SATS model considers the travel along segments of roadway and generates figures of vehicle miles traveled (VMT) along each segment. Inputs to the SATS model include the nature of each trip; for example, going to work, going shopping, etc. It considers the traffic mode of the trip, and it is also able to estimate the variations in fuel usage due to socio-economic factors for different neighborhoods in the metropolitan area under consideration. See Figure 3 for the steps in the SATS modeling process. A comprehensive discussion of the Sacramento Area Transportation Study model is available (8).

The DTIM model takes, for each grid square, the VMT generated by the SATS model and calculates the amount of air pollution emitted from the aggregate of motor vehicles. DTIM bases its calculations on emission factors used by the ARB and Caltrans. The program prints a report on the quantity of air pollutants being emitted in a geographical area, and it also writes, on magnetic tape, a file of hourly gridded mobile source emissions. The ARB modeling staff applied hydrocarbon splitting factors to produce a file that is used by the SMOG photochemical model.

The effect of proposed transportation control measures on vehicular emissions can be estimated by using the SATS and DTIM models. The VMT will be reduced or increased for input into DTIM according to the SATS analysis of the transportation control measure.

Table 1 and Figures 4 through 14 show data on emissions from sources in the Sacramento region.

TABLE 1

Emissions Summary for August 24, 1976
(Kilograms/day)

Emission Category No.	Description	CO	NO_x	THC
2	Motor vehicle	397,909	39,594	47,089
122	Gas evaporation fuel tank	0	0	2,958
58	Industrial off-road motor vehicles	22,259	3,645	1,309
59	Construction off-road motor vehicles	11,915	10,622	1,246
61	Farm off-road motor vehicles	24,288	2,133	3,467
33	Shipping: off-loading	43	43	33
121	Pleasure craft	15,989	119	6,884
4	Railroad	2,566	3,541	1,281
20	Jet exhaust	3,188	1,964	1,700
63	Jet fuel evaporation	0	0	142
19	Piston aircraft exhaust	2,925	11	50
129	Piston aircraft fuel evaporation	0	0	63
10	Petroleum marketing	0	0	3,400
40	Petroleum marketing: underground storage	0	0	1,271
45	Auto & station refilling	0	0	5,122
16	Commercial and industrial surface coatings-air dried	0	0	531
46	Petroleum based dry cleaning	0	0	1,520
43	Synthetic dry cleaning	0	0	805
42	Halogenated degreasing	0	0	1,759
47	Non-halogenated degreasing	0	0	2,339
5	Industrial (general)	43	465	981
49	Industrial external combustion boilers	45	1,135	104
71	Industrial external combustion boilers-natural gas	122	1,462	11
15	Chemical industry	0	33	2,280
31	Mineral industry	0	69	0
41	Industrial surface coating-air dried	0	0	1,835
51	Industrial incineration	12	4	4
17	Wildfire or agricultural burn	249	11	78
24	Pesticides	0	0	446
32	Food processing	57	614	86
27	Waste burning	40	0	7
26	Domestic solvent use	0	0	1,102
53	Domestic utility 2-stroke engines	857	0	385
52	Domestic utility 4-stroke engines	7,372	66	627
62	Domestic fuel combustion	268	1,166	102
	TOTAL	490,147	66,697	91,017

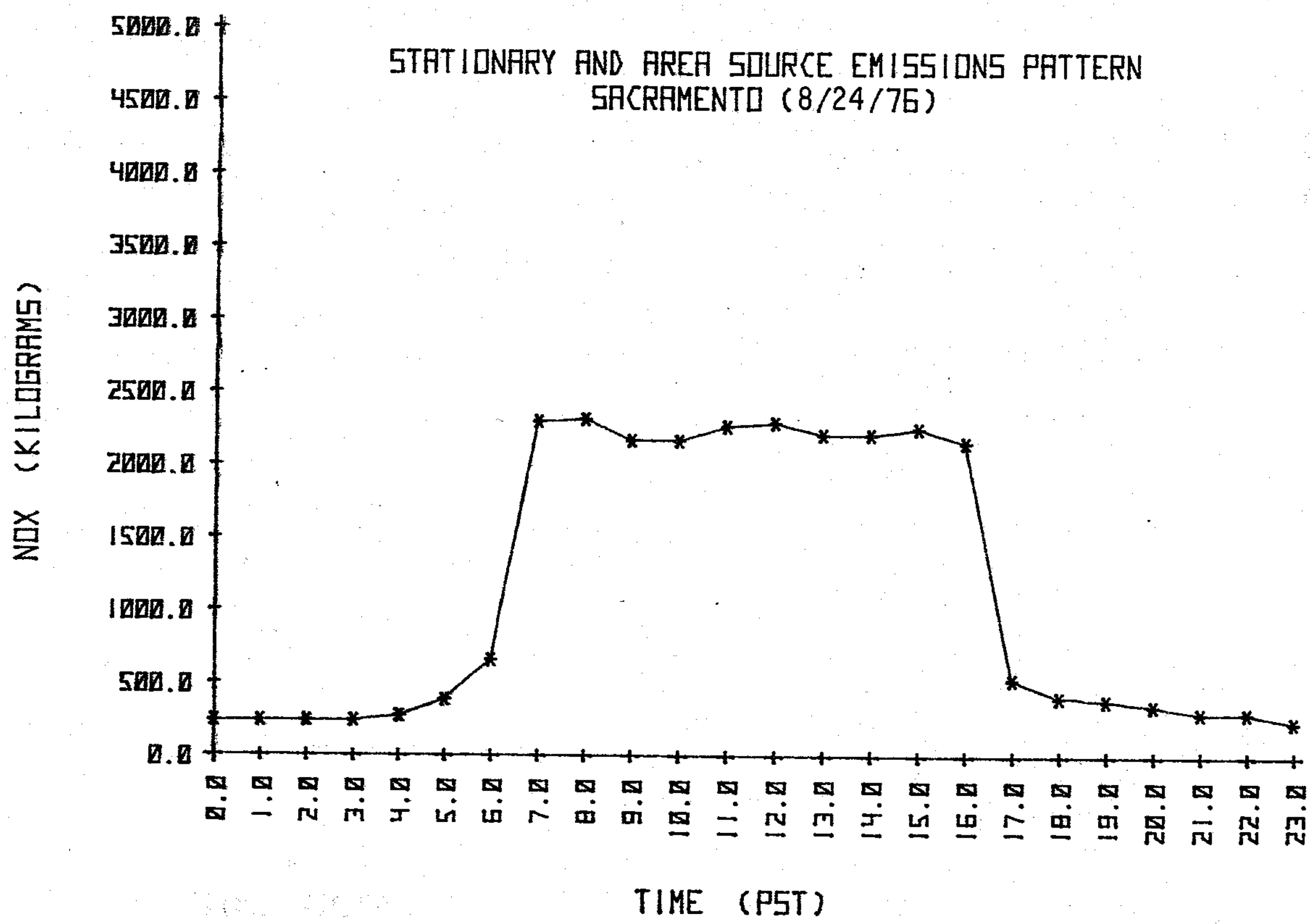

STATIONARY AND AREA SOURCE EMISSIONS PATTERN
SACRAMENTO (8/24/76)
NOX (KILOGRAMS)
5000.0
4500.0
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
TIME (PST)

FIGURE 4

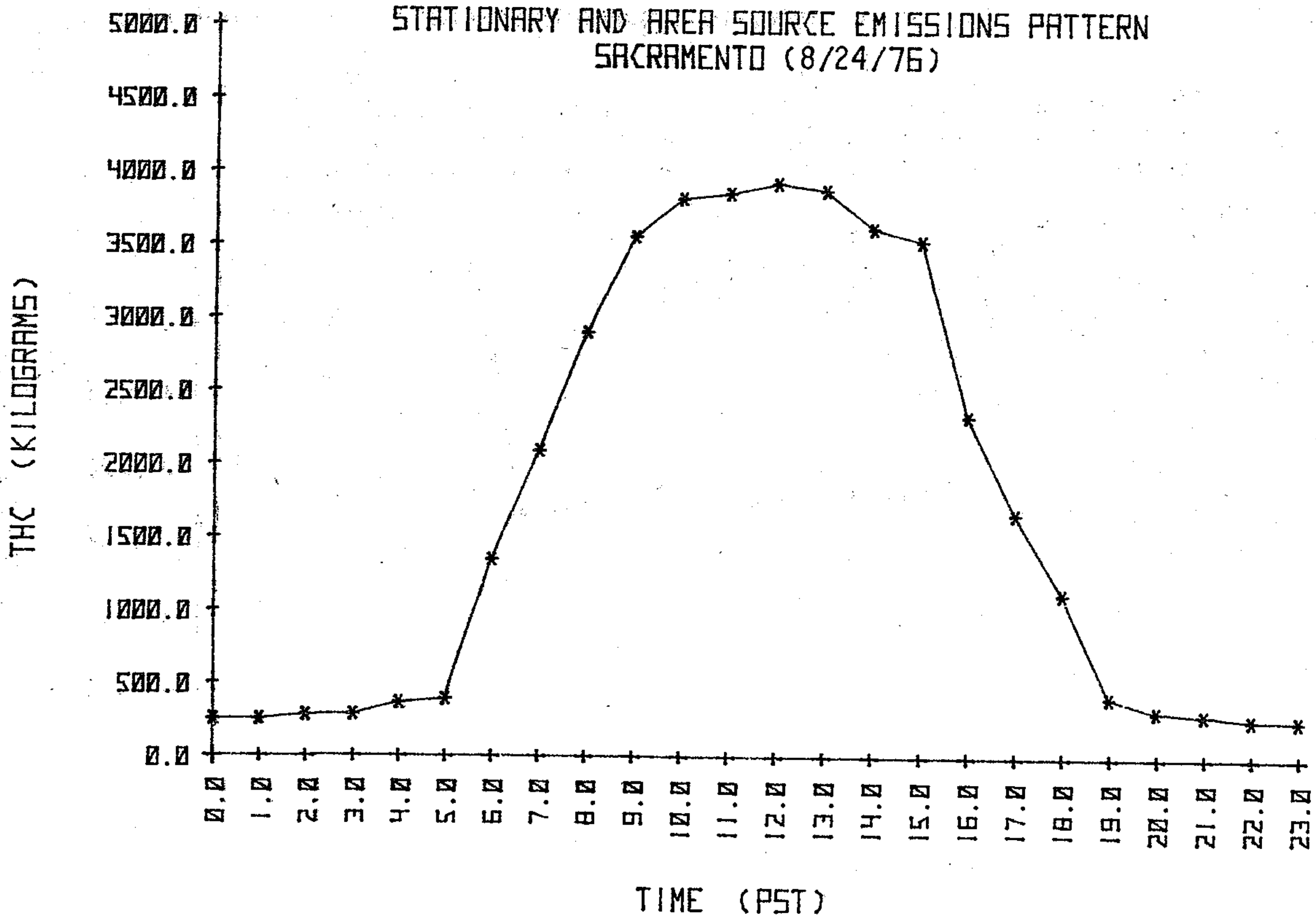

STATIONARY AND AREA SOURCE EMISSIONS PATTERN
SACRAMENTO (8/24/76)
THC (KILOGRAMS)
5000.0
4500.0
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0
TIME (PST)

FIGURE 5

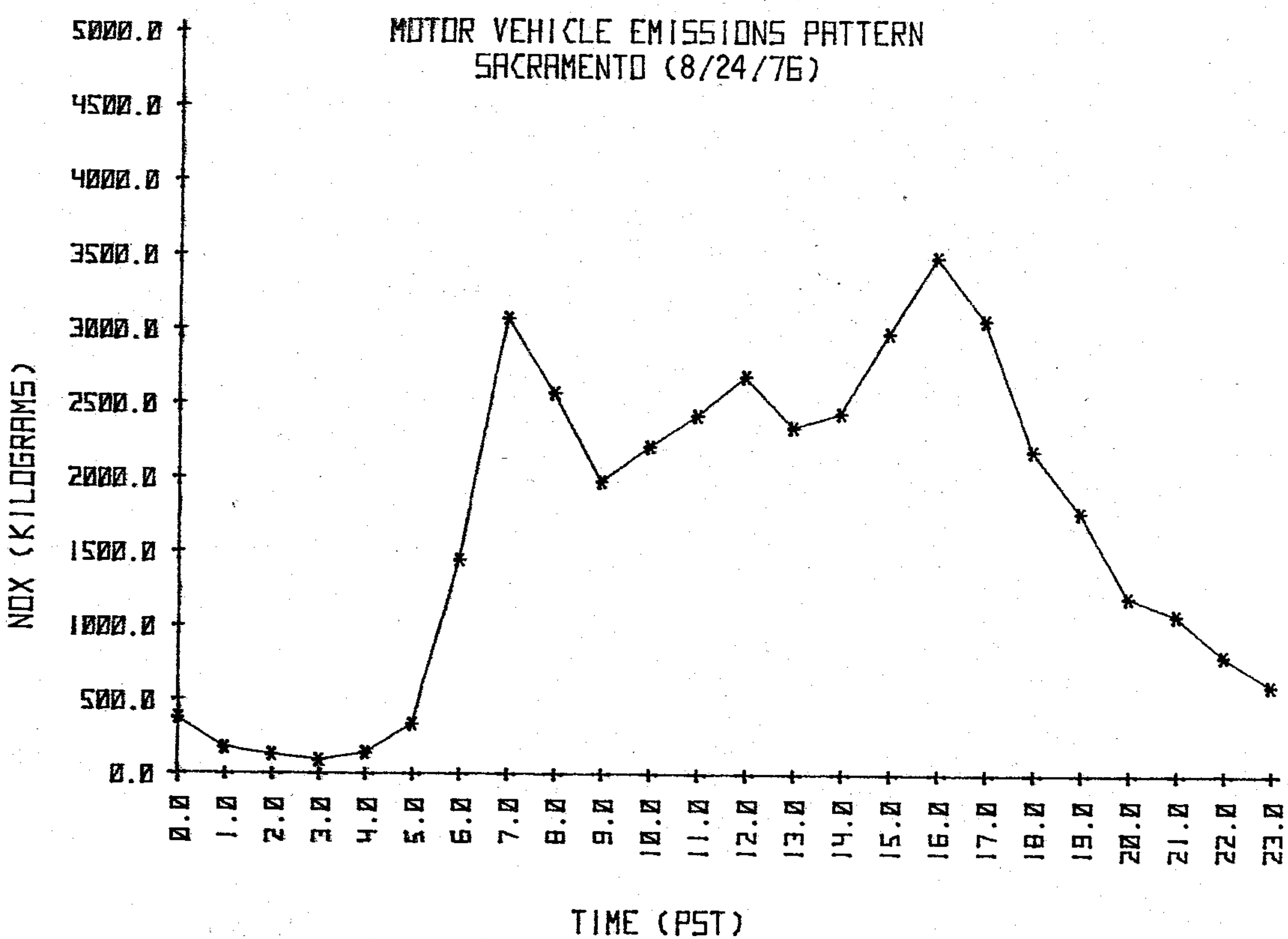

MOTOR VEHICLE EMISSIONS PATTERN
SACRAMENTO (8/24/76)
NOX (KILOGRAMS)
5000.0
4500.0
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
TIME (PST)

FIGURE 6

MOTOR VEHICLE EMISSIONS PATTERN
SACRAMENTO (8/24/76)

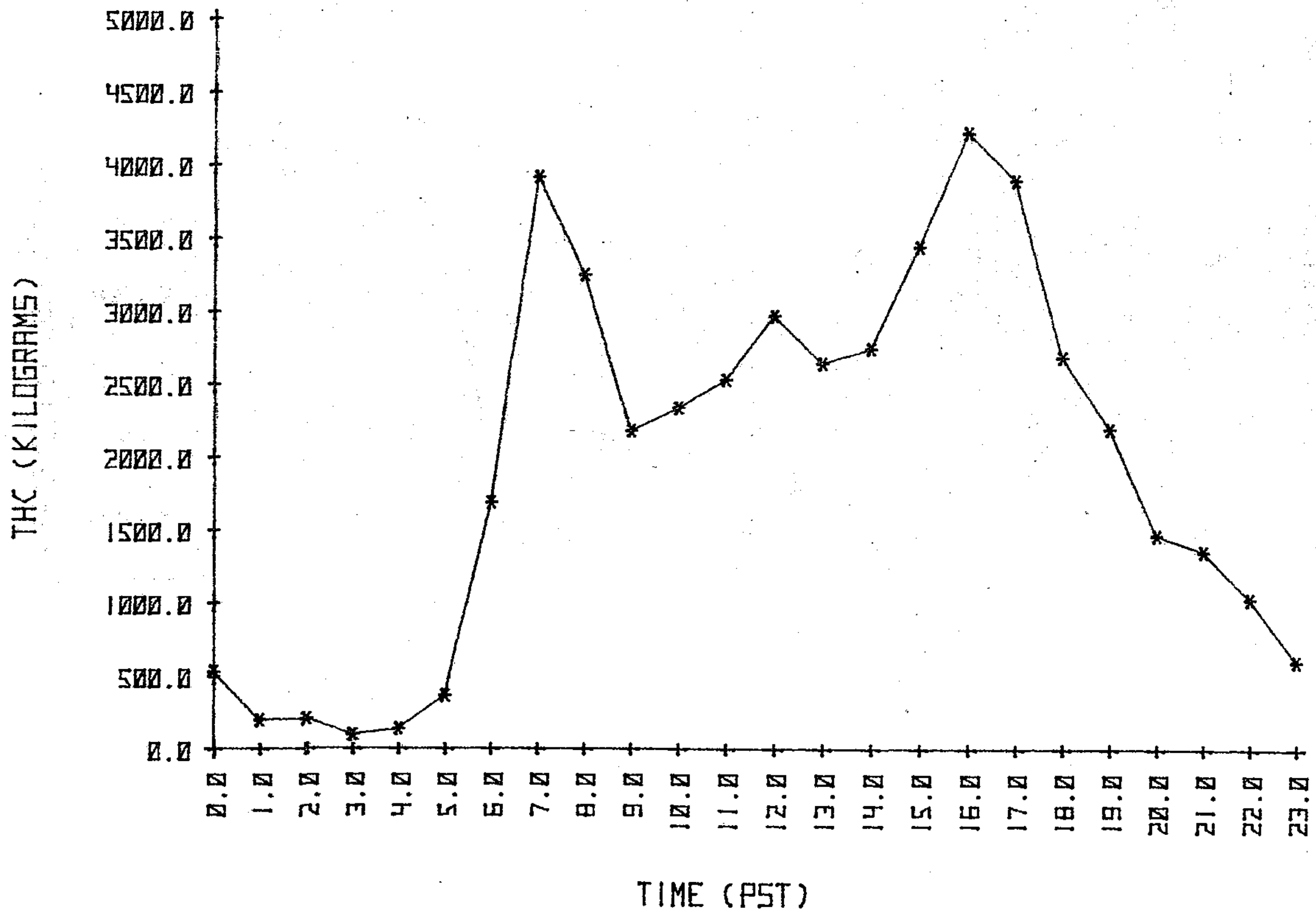


FIGURE 7

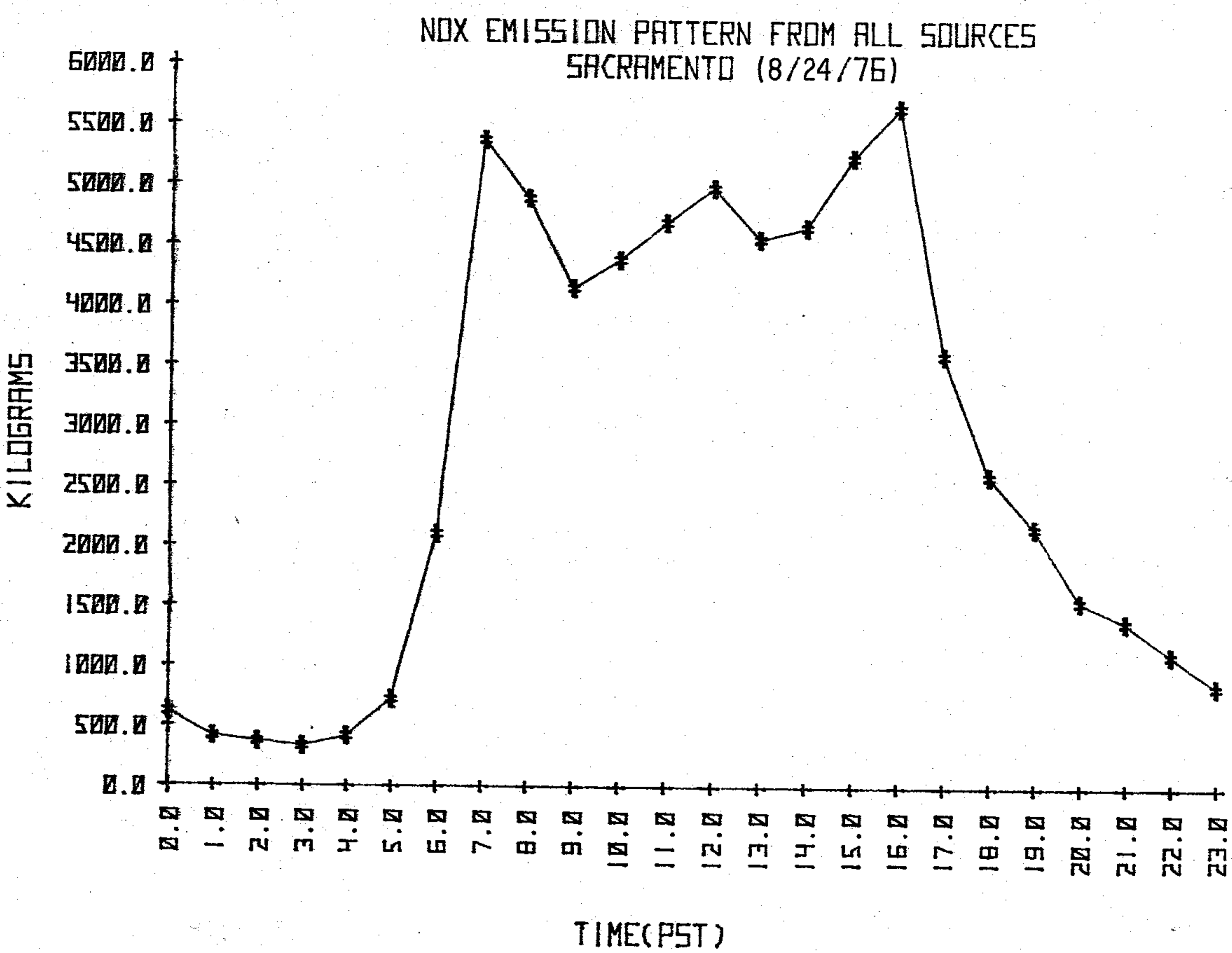

NOX EMISSION PATTERN FROM ALL SOURCES
SACRAMENTO (8/24/76)
KILOGRAMS
6000.0
5500.0
5000.0
4500.0
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
TIME(PST)

FIGURE 8

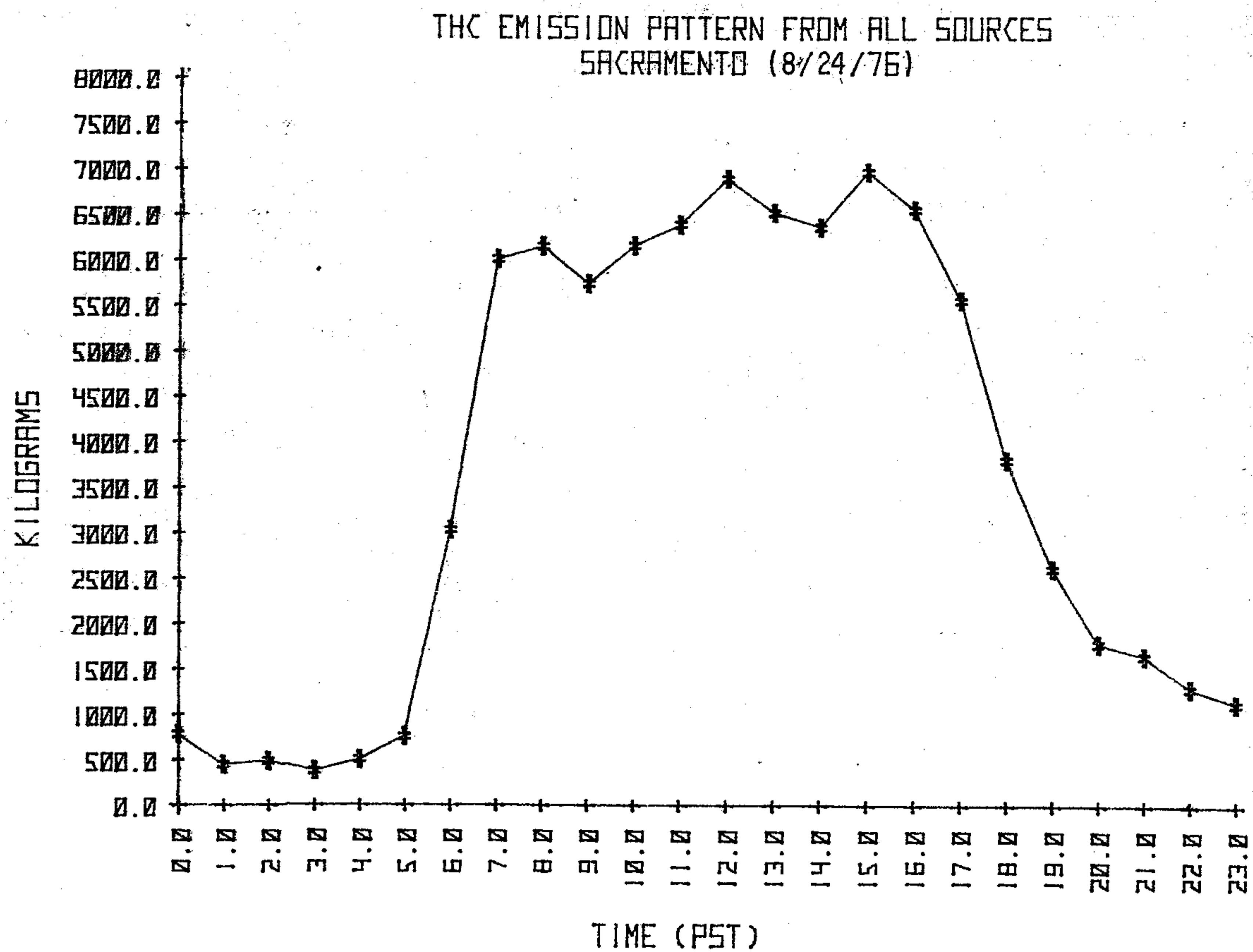

THC EMISSION PATTERN FROM ALL SOURCES
SACRAMENTO (8/24/76)
KILOGRAMS
8000.0
7500.0
7000.0
6500.0
6000.0
5500.0
5000.0
4500.0
4000.0
3500.0
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0
TIME (PST)

FIGURE 9

SACRAMENTO REGION
SUMMARY OF MSDS EMISSIONS BY GRID CELL
OXIDES OF NITROGEN EMISSION PATTERN FROM ALL SOURCES IN KG/DAY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
25	11	13	13	11	11	86	14	35	0	0	0	0	0	7	7	48	7	14	206	113	22	11	11	8	3	25
24	11	11	13	13	11	31	11	36	0	0	0	0	0	7	7	40	28	224	81	241	12	17	13	8	0	24
23	11	11	11	13	11	83	19	40	1	2	1	3	1	8	11	93	319	293	42	59	33	43	12	5	1	23
22	11	11	12	11	11	30	12	36	30	18	14	11	28	11	34	156	406	87	21	44	19	27	6	6	3	22
21	11	11	465	4	6	79	11	34	73	114	24	43	27	2	141	499	266	366	101	22	2	18	7	6	12	21
20	11	12	463	534	0	73	11	32	38	94	35	106	181	409	543	494	242	378	243	321	39	73	25	15	3	20
19	141	124	18	9	4	89	22	31	70	99	38	147	177	529	644	574	664	503	432	367	169	111	19	0	0	19
18	11	21	130	131	135	241	13	29	30	104	79	276	797	969	617	263	330	480	170	259	195	40	11	9	44	18
17	11	11	23	30	15	81	138	95	189	274	256	494	376	370	454	282	348	195	26	220	132	76	80	78	51	17
16	11	11	11	27	24	38	314	96	84	183	514	457	292	449	385	201	197	198	177	355	53	0	3	1	0	16
15	11	11	11	11	29	140	174	248	263	588	783	414	326	169	370	53	351	280	0	15	34	3	0	1	0	15
14	11	11	11	11	133	236	677	757	576	599	202	192	191	203	137	318	413	102	8	6	0	0	0	1	0	14
13	11	279	393	393	432	348	562	1439	942	277	347	236	327	582	449	242	389	90	37	4	7	0	0	0	0	13
12	379	118	11	10	3	128	25	291	1126	468	603	490	477	338	286	81	299	302	66	0	1	0	0	0	1	12
11	11	11	11	9	10	23	86	292	699	202	271	488	179	217	230	36	25	74	64	0	1	0	0	0	1	11
10	11	11	11	9	19	40	154	227	621	398	217	284	152	116	95	29	36	28	39	1	2	0	0	0	1	10
9	11	11	11	18	8	34	69	186	244	489	256	139	119	79	60	19	20	14	16	45	38	34	15	15	16	9
8	11	11	11	20	3	3	11	120	98	167	409	154	156	46	49	21	20	12	17	8	6	10	10	1	1	8
7	11	11	11	18	3	3	3	26	6	56	53	226	63	43	50	22	26	23	7	4	6	3	1	9	8	7
6	11	11	11	14	3	3	14	13	0	42	4	238	85	151	61	43	42	14	0	4	10	3	0	1	1	6
5	11	11	10	12	3	166	33	5	12	44	0	97	224	118	39	114	25	4	4	15	8	1	0	1	1	5
4	11	11	9	15	5	457	13	2	11	54	21	19	428	465	44	13	2	23	20	9	5	2	1	0	0	4
3	11	11	5	14	3	3	14	3	8	55	13	15	74	281	37	1	5	100	10	11	3	2	1	0	0	3
2	11	9	3	14	3	3	18	4	11	54	12	16	16	235	73	1	2	1	2	4	2	2	1	0	0	2
1	11	8	3	15	3	4	17	0	3	49	11	11	11	10	249	1	0	0	1	2	0	0	0	3	2	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	

GRID TOTAL = 66613 KILOGRAMS/DAY

FIGURE 10

SACRAMENTO REGION
SUMMARY OF MSDS EMISSIONS BY GRID CELL
TOTAL HYDROCARBON EMISSION PATTERN FROM ALL SOURCES IN KG/DAY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
25	20	172	97	18	18	50	19	26	0	0	0	0	1	1	1	21	1	45	427	107	42	11	12	2	0	25
24	20	20	140	143	18	48	18	100	0	0	0	0	0	1	2	44	36	2030	36	58	19	11	15	2	0	24
23	20	20	20	169	10	51	34	31	0	6	1	2	1	4	10	239	939	377	28	93	49	92	103	160	22	23
22	20	20	169	20	18	49	20	27	19	14	10	6	13	13	42	273	536	148	62	31	32	73	186	186	103	22
21	20	20	311	4	10	45	18	23	40	54	23	43	55	2	57	356	322	189	24	17	2	55	150	186	53	21
20	20	140	235	256	0	40	18	26	38	158	37	86	334	155	195	290	242	171	176	127	79	74	46	59	22	20
19	79	225	20	20	3	48	24	32	59	103	46	198	459	319	650	605	425	459	192	210	222	323	16	0	0	19
18	20	35	306	79	73	125	20	34	15	102	43	464	3151	899	521	413	450	346	132	200	49	28	4	6	22	18
17	20	20	24	179	174	58	81	51	117	275	327	253	804	363	410	426	170	265	44	100	119	35	39	37	24	17
16	20	20	20	27	173	50	162	127	142	357	510	723	436	443	415	113	128	148	84	970	18	0	1	0	0	16
15	20	20	20	20	144	231	252	110	287	927	2310	900	816	392	264	108	545	160	0	2289	12	2	0	0	0	15
14	20	20	20	20	150	296	460	1571	730	314	258	673	439	337	125	521	244	43	4	12	0	0	0	0	0	14
13	20	107	160	160	312	516	1230	2241	1635	775	616	501	486	396	716	187	402	32	13	1	2	0	0	0	0	13
12	155	71	20	19	5	227	272	639	1272	567	951	532	453	255	141	30	575	494	28	0	0	0	0	0	0	12
11	20	20	20	17	10	33	325	654	772	592	653	194	381	87	100	21	16	25	28	0	0	0	0	0	0	11
10	20	20	20	17	21	254	506	412	1475	770	455	439	174	59	51	25	25	20	25	0	3	0	0	0	0	10
9	20	20	20	22	126	86	191	492	501	712	639	142	102	40	46	24	24	19	21	36	25	24	6	7	8	9
8	20	20	20	23	5	159	161	289	173	260	370	243	42	41	40	23	23	18	19	8	2	7	9	0	0	8
7	20	20	20	19	5	5	5	199	21	30	137	116	35	35	40	23	25	24	11	1	2	1	0	5	5	7
6	20	20	20	14	7	5	131	158	0	21	5	151	55	75	56	47	42	27	5	1	3	3	0	0	0	6
5	20	20	19	10	5	5	189	8	18	21	0	52	75	63	37	40	23	7	2	22	3	0	0	0	0	5
4	20	20	17	13	7	59	195	2	22	39	31	30	159	245	48	22	6	13	12	3	2	1	0	0	0	4
3	20	20	10	11	5	5	281	120	17	41	24	26	48	99	35	5	2	23	3	5	1	1	0	0	0	3
2	20	13	5	12	7	5	174	3	17	41	23	27	25	112	37	0	1	0	0	2	1	1	0	0	0	2
1	20	14	5	13	5	124	168	0	10	39	24	23	23	21	98	0	2	0	0	8	0	0	0	1	0	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	

GRID TOTAL = 87945 KILOGRAMS/DAY

FIGURE 11

SACRAMENTO REGION

SUMMARY OF MSDS EMISSIONS BY GRID CELL

SULFUR OXIDES EMISSION PATTERN FROM ALL SOURCES IN KG/DAY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
25	1	3	2	1	1	4	1	1	0	0	0	0	0	0	0	6	0	0	18	4	0	0	0	0	0	25
24	1	1	2	2	1	4	1	2	0	0	0	0	0	0	0	6	5	24	3	34	0	0	0	0	0	24
23	1	1	1	2	1	4	1	1	0	0	0	0	0	0	0	696	1409	13	1	1	0	0	1	1	0	23
22	1	1	2	1	1	5	2	2	1	1	1	0	2	0	0	1401	18	3	0	1	0	0	1	1	1	22
21	1	1	2	0	0	4	1	1	1	7	0	1	0	0	9	26	14	25	7	0	0	0	1	1	0	21
20	1	2	2	5	0	3	1	1	2	2	1	4	7	19	34	30	13	25	16	23	0	1	0	0	0	20
19	7	7	1	0	0	4	1	1	2	2	1	4	6	25	31	32	43	31	30	25	9	4	1	0	0	19
18	1	1	7	6	7	12	1	2	0	3	3	6	33	54	38	12	16	30	10	17	14	2	0	0	1	18
17	1	1	1	2	2	4	6	4	8	11	11	18	43	17	29	13	24	7	1	12	6	3	3	3	2	17
16	1	1	1	1	2	1	15	3	2	5	13	18	12	28	25	14	14	9	8	6	3	0	0	0	0	16
15	1	1	1	1	2	8	8	5	9	19	36	19	12	6	25	1	17	16	0	1	2	0	0	0	0	15
14	1	1	1	1	3	4	6	22	16	21	8	6	7	8	8	13	24	5	0	0	0	0	0	0	0	14
13	1	9	15	15	15	14	27	52	35	8	13	9	14	33	23	14	5	5	2	0	0	0	0	0	0	13
12	14	6	1	1	0	40	2	11	50	20	23	21	18	22	19	5	4	4	4	0	0	0	0	0	0	12
11	1	1	1	1	0	0	3	10	32	7	9	8	9	13	8	1	1	4	3	0	0	0	0	0	0	11
10	1	1	1	1	0	1	6	8	25	16	8	6	6	5	5	1	1	0	1	0	0	0	0	0	0	10
9	1	1	1	1	1	0	1	6	8	22	10	5	5	3	3	1	1	1	1	2	1	1	0	0	0	9
8	1	1	1	1	0	1	1	3	2	6	20	10	8	2	2	2	1	1	1	0	0	0	0	0	0	8
7	1	1	1	1	0	0	0	1	0	1	2	11	2	2	3	2	2	1	0	0	0	0	0	0	0	7
6	1	1	1	0	0	0	1	1	0	1	0	12	3	9	3	2	2	1	0	0	1	0	0	0	0	6
5	1	1	1	0	0	0	2	0	1	1	0	4	14	5	2	9	0	0	0	1	0	0	0	0	0	5
4	1	1	1	0	0	0	1	0	1	2	1	1	27	29	2	0	0	1	1	1	0	0	0	0	0	4
3	1	1	0	0	0	0	2	1	1	2	1	1	4	11	2	0	0	8	1	1	0	0	0	0	0	3
2	1	1	0	0	0	0	1	0	0	2	1	1	1	11	4	0	0	0	0	0	0	0	0	0	0	2
1	1	1	0	0	0	1	2	0	0	1	1	1	1	1	11	0	0	0	0	0	0	0	0	0	0	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	

GRID TOTAL = 6508 KILOGRAMS/DAY

FIGURE 12

SACRAMENTO REGION

SUMMARY OF MSDS EMISSIONS BY GRID CELL

CARBON MONOXIDE EMISSION PATTERN FROM ALL SOURCES IN KG/DAY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
25	126	461	283	128	128	496	143	195	1	4	1	1	4	29	20	236	20	177	1495	753	302	78	62	23	0	25
24	126	126	381	377	120	466	123	347	2	5	1	1	1	28	35	361	278	1175	393	156	83	107	112	23	0	24
23	126	126	126	454	127	492	234	241	14	48	18	25	16	40	79	1056	3287	2350	283	534	276	565	338	498	70	23
22	126	126	444	131	119	467	139	203	185	145	108	80	189	66	343	962	3320	925	366	287	202	309	584	584	311	22
21	126	126	872	33	69	447	132	191	363	410	180	338	353	25	605	3157	1813	1236	207	157	10	295	495	584	215	21
20	126	382	713	922	3	425	130	191	357	1025	312	840	2029	1262	1893	2214	1681	1376	1274	1015	550	569	332	248	28	20
19	752	437	168	130	39	495	200	260	509	706	384	809	2640	2255	4701	3878	2866	2980	1463	1421	1134	1814	132	3	0	19
18	126	150	1206	759	756	1286	150	288	135	710	511	2782	4755	5511	3452	2332	2906	2390	1051	1083	817	332	76	67	238	18
17	126	126	162	527	480	533	1263	508	998	1992	2069	2520	6092	2986	2630	2940	1286	1670	336	897	1001	386	413	393	262	17
16	126	126	126	185	473	335	1615	976	947	2561	3874	4523	3180	2869	2353	759	725	1310	954	768	298	1	26	10	7	16
15	126	126	126	126	430	1063	1260	1040	2168	5495	7763	5319	5307	2502	1650	689	3332	1336	1	121	201	30	1	9	2	15
14	126	126	126	126	501	1463	2549	6728	4786	2701	1946	3760	2596	2186	764	3191	1563	627	63	100	0	8	0	9	0	14
13	126	976	1541	1540	1940	2951	4361	14130	10566	5056	4664	3208	3904	3053	2601	1520	1363	523	216	32	42	5	0	8	0	13
12	1492	681	126	122	38	709	817	4195	9598	4554	5267	4349	3512	1674	1136	482	1284	1201	404	0	9	2	2	2	10	12
11	126	126	126	104	93	260	1591	3332	6021	3474	4458	1757	1549	969	981	243	206	380	390	3	12	3	3	3	14	11
10	126	126	126	104	131	962	2508	4126	5400	4678	2702	1430	817	746	615	236	240	187	250	11	29	3	3	3	13	10
9	126	126	126	166	323	424	1109	2343	2581	4671	3667	1049	939	502	433	191	196	150	165	330	248	198	83	87	91	9
8	126	126	126	174	37	394	427	1745	823	1823	2737	661	369	387	373	197	191	142	156	93	35	76	93	4	4	3
7	126	126	126	154	37	37	39	577	131	282	812	1235	318	338	373	191	226	212	79	26	40	27	6	67	63	7
6	126	126	126	122	58	39	361	405	0	192	50	1405	428	613	462	378	343	168	0	22	65	37	3	4	7	6
5	126	126	122	100	37	44	626	69	132	197	10	539	835	608	301	325	176	26	31	189	53	4	3	4	3	5
4	126	126	104	123	59	116	418	20	120	307	220	200	1577	1440	391	142	12	159	152	60	32	11	4	3	3	4
3	126	126	58	103	37	40	667	262	89	312	136	168	444	1174	286	7	36	230	58	78	18	14	8	3	3	3
2	126	113	37	111	52	37	509	39	95	312	137	177	165	1108	378	12	21	5	6	29	12	14	8	3	6	2
1	126	91	37	121	37	292	466	0	39	284	136	135	127	113	1089	12	21	0	0	60	0	2	2	18	14	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	

GRID TOTAL = 490261 KILOGRAMS/DAY

FIGURE 13

SACRAMENTO REGION

SUMMARY OF MSDS EMISSIONS BY GRID CELL

PARTICULATE EMISSION PATTERN FROM ALL SOURCES IN KG/DAY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	1	1	1	1	1	8	1	2	0	0	0	0	0	15	29	19	15	1	63	194	3	2	3	1	0
24	1	1	1	1	1	8	1	2	0	0	0	0	0	15	1	4	15	32	9	34	3	2	2	1	0
23	1	1	1	1	1	8	1	2	0	0	0	0	0	16	16	248	515	37	5	12	11	7	3	0	0
22	1	1	1	2	2	9	2	3	2	2	1	0	2	5	5	494	52	12	6	8	4	5	0	0	0
21	1	1	21	0	1	8	1	1	4	8	2	4	2	0	13	56	29	33	7	2	0	2	0	0	1
20	1	1	21	25	0	8	1	1	2	7	4	9	23	34	54	49	28	35	21	26	4	7	2	1	0
19	15	14	1	0	0	10	2	3	5	8	4	16	21	47	84	58	64	52	36	35	15	12	1	0	0
18	1	1	12	14	15	28	1	3	1	10	6	25	69	111	65	27	40	50	16	24	15	3	0	1	4
17	1	1	1	1	1	8	14	11	21	30	32	48	115	45	48	30	31	23	2	22	14	8	9	8	5
16	1	1	1	1	1	3	36	10	8	20	59	61	41	45	36	16	14	24	19	16	3	0	0	0	0
15	1	1	1	1	2	15	20	23	29	65	110	50	43	22	34	4	39	29	0	1	2	0	0	0	0
14	1	1	1	1	9	15	24	62	55	61	29	24	27	31	11	41	41	6	0	0	0	0	0	0	0
13	1	19	33	33	38	39	73	155	121	33	47	33	50	58	52	24	16	5	2	0	0	0	0	0	0
12	31	13	1	1	0	19	1	40	146	65	72	64	61	28	25	5	19	19	4	0	0	0	0	0	0
11	1	1	1	1	0	1	9	36	95	25	35	20	18	18	15	4	1	4	3	0	0	0	0	0	0
10	1	1	1	1	1	3	20	30	74	51	31	20	9	8	7	2	4	2	4	0	0	0	0	0	0
9	1	1	1	1	0	1	7	24	27	64	33	12	12	5	6	1	1	1	1	4	4	3	1	1	1
8	1	1	1	2	0	0	1	14	11	23	52	14	9	3	4	2	1	1	1	0	0	0	0	0	0
7	1	1	1	2	0	0	0	2	0	5	7	26	2	4	5	2	2	1	1	0	0	0	0	0	0
6	1	1	1	1	0	0	1	1	0	3	0	34	6	13	7	3	3	1	0	0	1	0	0	0	0
5	1	1	1	1	0	0	3	0	1	3	0	10	20	8	3	8	2	0	0	1	0	0	0	0	0
4	1	1	1	1	0	0	0	0	1	4	1	1	39	31	3	1	0	2	2	1	0	0	0	0	0
3	1	1	0	1	0	0	0	0	1	4	1	1	8	22	3	0	0	7	1	1	0	0	0	0	0
2	1	1	0	1	0	0	0	0	1	4	1	1	1	21	7	0	0	0	0	0	0	0	0	0	0
1	1	1	0	1	0	0	1	0	0	4	1	1	1	1	24	0	0	0	0	0	0	0	0	0	0

GRID TOTAL = 8287 KILOGRAMS/DAY

FIGURE 14

AEROMETRIC DATA BASE

In order to verify a regional air quality model, it is necessary to rationally determine the ambient air quality and associated meteorological conditions throughout the study area. This process is referred to as development of a data base. Then, when the predictions from the air quality simulation program are computed, the predicted pollutant concentrations can be compared with the known concentrations and the efficacy of the simulation model can be judged. In order to establish such a data base for the Sacramento study, several locations were monitored during the summer of 1976. The monitoring was a joint effort of the Transportation Laboratory and the Caltrans District 03 (Marysville) office. Other air quality data were received from the ARB downtown station, the monitoring stations of the Sacramento APCD and the Yolo-Solano APCD, and from a monitoring effort at the Rancho Seco nuclear generator.

Air Quality Monitoring

The Transportation Laboratory stationed three trailers containing pollutant monitoring equipment in locations outside the urban Sacramento core area. One was operated on Meadowview Road in the south area at the site of the old California Highway Patrol Academy, the second was operated north of Sacramento adjacent to I-880 at the Northgate Boulevard Interchange, and the third was at the Placer County Fairgrounds in Roseville. The mobile air monitoring van operated by Caltrans District 03 divided its time between the Lincoln Airport north of Roseville in Placer County and a site near the community of Wilton, in the southeast portion of the study area. These monitoring facilities are shown in Figures 15 and 16.

FIGURE 15 Mobile Air Monitoring Van

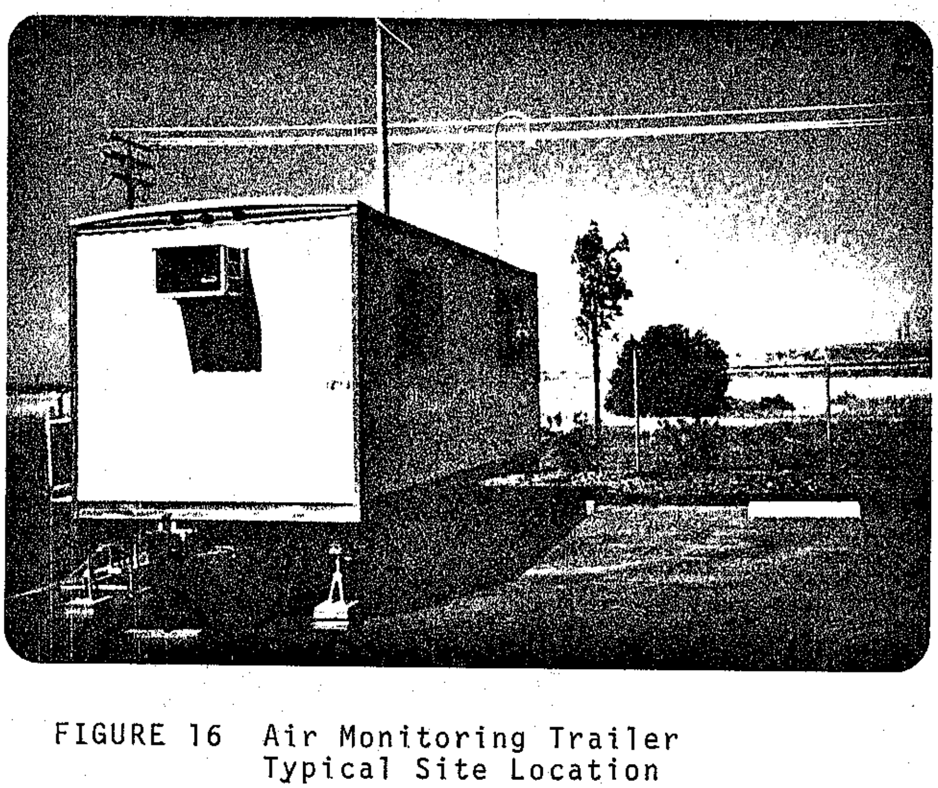


FIGURE 16 Air Monitoring Trailer
Typical Site Location

Each of these four monitoring units had the capability of monitoring ozone, oxides of nitrogen, hydrocarbons, and carbon monoxide. Sampling device descriptions are in Table 2. The ARB's downtown station at 10th and "P" monitored ozone and carbon monoxide. The Sacramento APCD monitoring station at Creekside School near Fulton and Marconi in the Sacramento northeast area also monitored ozone and carbon monoxide. The same pollutants were measured in Davis, California, by the Yolo-Solano APCD. The Sacramento Municipal Utility District had a contractor operating a station at their Rancho Seco nuclear plant and monitored ozone, oxides of nitrogen, and carbon monoxide. The Caltrans data were placed on magnetic tape as they were measured while the other information was delivered as written monthly reports.

Meteorologic Data

Twelve stations were established to gather wind speed, wind direction, and temperature data. These stations are located throughout the study area. Ten of them utilized the mechanical weather stations (MWS) produced by Meteorology Research, Inc. (MRI) which are self-contained battery-driven units which record wind speed, wind direction, and temperature data on paper tape. Two of the stations were steel towers with attached meteorologic equipment to measure wind speed, wind direction, and temperature at two different levels. Thus, these towers enabled the air quality engineer to determine the temperature gradient with elevation and the wind speed gradient with elevation at the tower sites. The towers were placed at the Transportation Laboratory in the eastern Sacramento urban area and the

TABLE 2

Type of Instrumentation Used in Air Quality Data Collection

	ARB	APCD	CALTRANS
Ozone			
Instrument	Dasibi 1003AH	Dasibi 1003AH	Dasibi 1003AH
Technique	UV absorption	UV absorption	UV absorption
Calibration	once every 6 mos.	once every 6 mos.	checked every other day. Calibrated by AIHL every 3 mos.
NO_x			
Instrument	TECO 14B	Not measured	Monitor Labs 8440
Technique	Chemiluminescent		Chemiluminescent
Calibration	Once every 6 mos.		weekly
THC			
Instrument	Power Designs	Not measured	Bendix 8201
Technique	Flame Ionization		Flame Ionization
Calibration	zeroed and spanned on a weekly basis		zeroed and spanned on a weekly basis
CO			
Instrument	Bendix 8501	Bendix 8501	Beckman 865
Technique	NDIR	NDIR	NDIR
Calibration	zeroed and spanned on a weekly basis	zeroed and spanned twice weekly	checked every other day

new Highway Patrol Academy in Yolo County near the Bryte Bend Bridge over the Sacramento River. These data were also supplemented by information from Rancho Seco and the local APCDs.

Solar radiation (insolation) was measured using a detector on the roof of the Transportation Laboratory building.

Table 3 lists the stations that were used to gather data for the study and Figure 17 shows the locations of the stations.

The purpose of the trailer at the Meadowview Road site was to monitor pollutant concentrations in the upwind air before passing through the Sacramento metropolitan area. The Roseville station measured the downwind pollutant concentrations after advection of the air through the Sacramento metropolitan area. Thus, the upwind Meadowview readings can be viewed as the background concentrations, and the downwind Roseville readings can be considered the pollutant concentrations after the pollutant emission contributions from metropolitan Sacramento.

TABLE 3

Monitoring Stations

Area-Site	Station Name	U.S.G.S. Quad	I UTM(east)	I Grid Unit	J UTM(north)	J Grid Unit
6580-001	Northgate	Rio Linda	632,800	8.40	4,277,700	16.35
6500-002	Roseville(Fair Grounds)	Roseville	648,250	16.13	4,291,050	23.03
6580-003	Meadowview	Florin	633,500	8.75	4,259,900	7.45
2550-004	Del Campo High	Citrus Heights	647,250	15.63	4,279,500	17.25
6350-005	Rio Linda	Rio Linda	635,450	9.73	4,281,750	18.38
6500-006	Roseville Met	Roseville	651,870	17.94	4,292,350	23.68
8840-007	Yolo Causeway	Davis	618,250	1.13	4,268,850	11.93
6580-008	TransLab	Sacramento E.	636,800	10.40	4,268,270	11.64
6580-014	Sacramento ARB	Sacramento E.	630,800	7.40	4,270,400	12.70
6600-015	Sacramento APCD(Creekside)	Sacramento E.	639,600	11.80	4,274,700	14.85
8840-021	Deep Water Channel	Sacramento W.	623,600	3.80	4,263,800	9.40
6600-022	Wilton	Elk Grove	650,170	17.09	4,250,720	2.86
6600-023	Rancho Murieta	Folsom S.E.	665,640	24.82	4,264,150	9.58
6600-024	I-5 Rest Area	Taylor Monument	620,830	2.42	4,280,975	17.99
5940-025	Lincoln Airport	Lincoln	643,000	13.50	4,307,000	31.00
8840-026	New Highway Patrol Academy	Sacramento W.	624,760	4.38	4,272,600	13.80
6600-027	Rancho-Seco (SMUD)	Clay	663,800	23.90	4,245,200	0.10
6600-028	Rancho-Seco (Met)	Goose Creek	665,300	24.65	4,245,600	0.30
1940-029	Davis-5th Street	Davis	610,000	-3.00	4,267,000	11.00

AIR QUALITY AND SURFACE WIND STATIONS

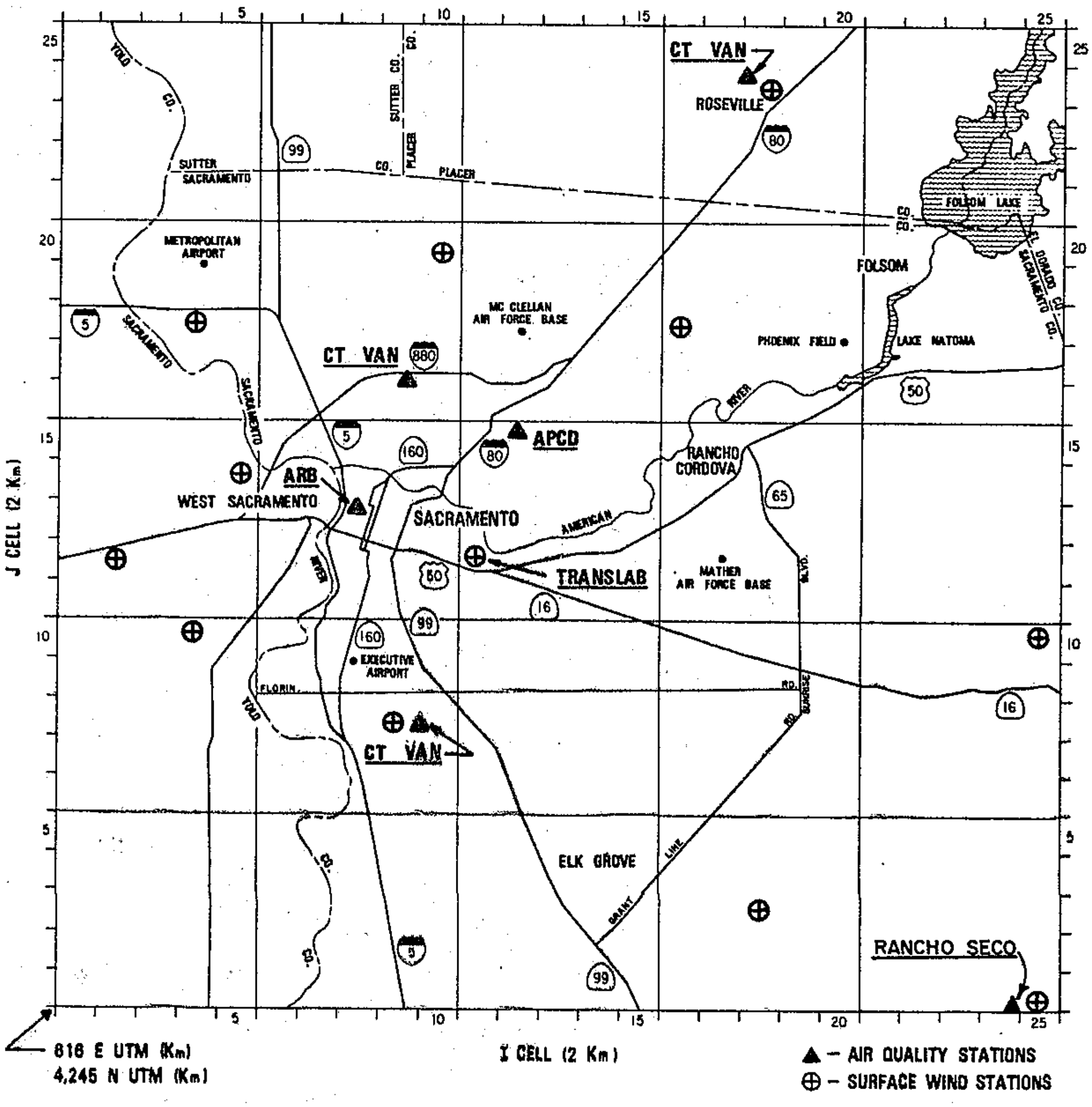


FIGURE 17

FIELD DATA PROCESSING (9)

Data Logger

The data loggers used on the Sacramento project are the Datel Model LPS-16 as modified by the California Transportation Laboratory. The data logger is a electrically powered tape recording device that can interface with a monitoring system. The output from ambient pollutant level analyzers or meteorologic equipment is placed on magnetic tape, and the tape is reduced by the use of a minicomputer. The minicomputer, using Basic computer language, prints out the readings in report form by type of pollutant or weather feature. These readings are then visually inspected for completeness and accuracy, and faulty data are removed. The edited data are then automatically placed into our Air Quality Data Handling System (AQDHS) computer file, through the use of another computer program.

During the data gathering effort for this project, the pollutant monitoring trailers and van as well as the steel tower meteorologic stations were equipped with data loggers. The MWS installations were not.

Digitizer

Wind and temperature data taken by the MWS (as opposed to electrically powered) devices, are reduced using a Graf-pen sonic digitizer. The digitizer is a device for determining X-Y coordinates in digital form for entries on a graphic record. The coordinates are entered automatically into a data processing minicomputer. The digitized coordinates are reduced, in the minicomputer, to recognizable formats of wind speed, wind direction, and temperature. The data are then recorded on a 7-track magnetic tape and placed into our AQDHS computer file.

Data Handling Files

Two important air quality data files were used in the modeling portion of this research project.

The AQDHS system was developed by the Environmental Protection Agency (EPA) at Research Triangle Park, North Carolina (10). It has provisions for handling and storing every type of air pollution-related data of general interest. AQDHS is considered a central file for all air quality data taken by Caltrans in the State of California. The Caltrans AQDHS file (11) is managed and maintained by the Transportation Laboratory, and most Caltrans District Environmental Branches store data in this file.

Caltrans air quality data taken in the field or received from other data gathering agencies are reduced to AQDHS format and put into the AQDHS computer file. AQDHS is programmed for adding, deleting, or changing data in the file. From this computer file, programs are available to print out written reports for distribution to interested agencies or individuals. Computer programs exist to access the file for use in various aspects of modeling work.

Modeling Study Data Staging (MSDS)(12) is a computer system developed by MAQU to store the information needed by a particular model for particular candidate modeling days. Rapid data access from MSDS to air quality models of any scale is the primary purpose of the MSDS system.

A computer program was developed for this research project which automatically converts the AQDHS file format to MSDS format. The MSDS file is also compatible with the Emission Inventory System (EIS) point source accounting effort (13). It is expected that point and area source data to be used in a computer modeling effort would be formatted directly for the MSDS file.

As an aid to the researcher/analyst of the meteorology of a region to be modeled, a computer program (14) was developed to select all the AQDHS meteorological data for a candidate day and print the magnitude and direction of the measured winds. After the wind data are taken from the AQDHS file, they are processed by the computer program, and vectors representing wind speed and direction are plotted using a Calcomp plotter.

The output from this plot program enables the air quality analyst to see the directions of the wind for each of the hours to be modeled. It also can serve to show the analyst that certain wind stations were perhaps not operating correctly, enabling him to remove the faulty data from the modeling data base.

CANDIDATE DAYS AND THE MODELING PROCESS

The selection of days for use in testing the simulation capability of photochemical models is determined from several considerations. Since one important desired end result of air pollution simulation model development is a verified model which can analyze various control strategies available to alleviate high ozone levels, the verification should be done for a day where ambient ozone measurements were unusually high.

Therefore, the first chore in selecting a candidate day is to review all days for which air pollution concentrations have been monitored with an eye toward selection of ozone episode days. Figures 18, 19, and 20 show the relative frequency of maximum ozone concentrations during June, July, August, and September 1976 at the Meadowview, Northgate and Roseville monitoring sites. In these figures, the relative frequency of 1.0 was assigned to the most frequent maximum ozone concentration range in the Sacramento region for the months studied. Thus, a relative frequency of 0.5 indicates that this range of ozone concentrations occurred one-half as often as did the most frequent range.

After the initial review designates the days of high ambient ozone concentration, the second step is to check the day of the week on which the high ozone concentrations were measured. In this step, the days where the data base will surely be incomplete (Saturdays and Sundays, for example) can be eliminated. Weekends do not qualify since employees are not working those days, and pilot balloons will not have been released, nor will temperature and pollutant monitoring aircraft have been flown on those days. Furthermore, the automated monitoring instrumentation will not have received its daily checkout.

FREQUENCY OF OCCURRENCE OF MAXIMUM
OZONE CONCENTRATIONS, JUNE THROUGH SEPT., 1976

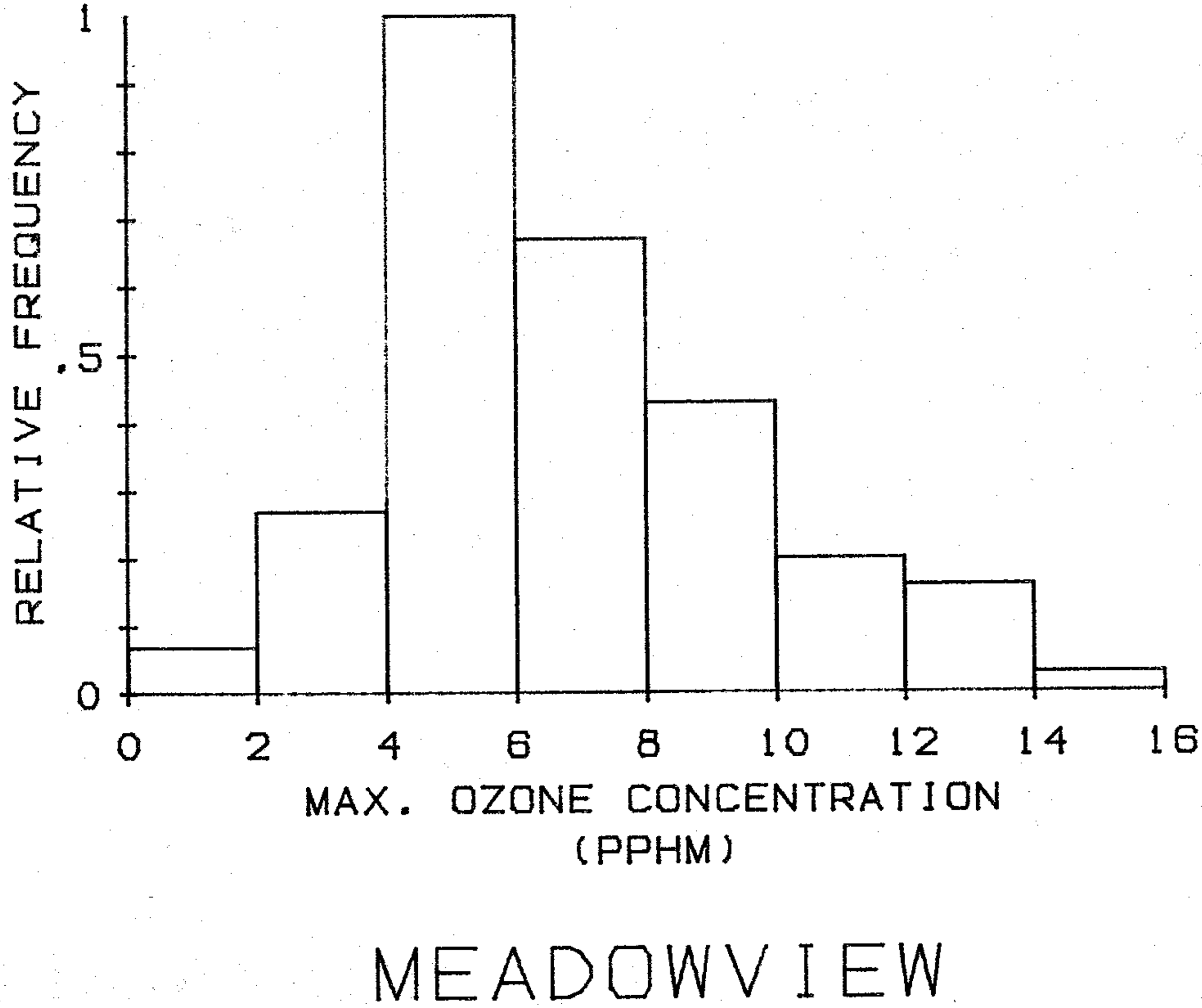


FIGURE 18

FREQUENCY OF OCCURRENCE OF MAXIMUM
OZONE CONCENTRATIONS, JUNE THROUGH SEPT., 1976

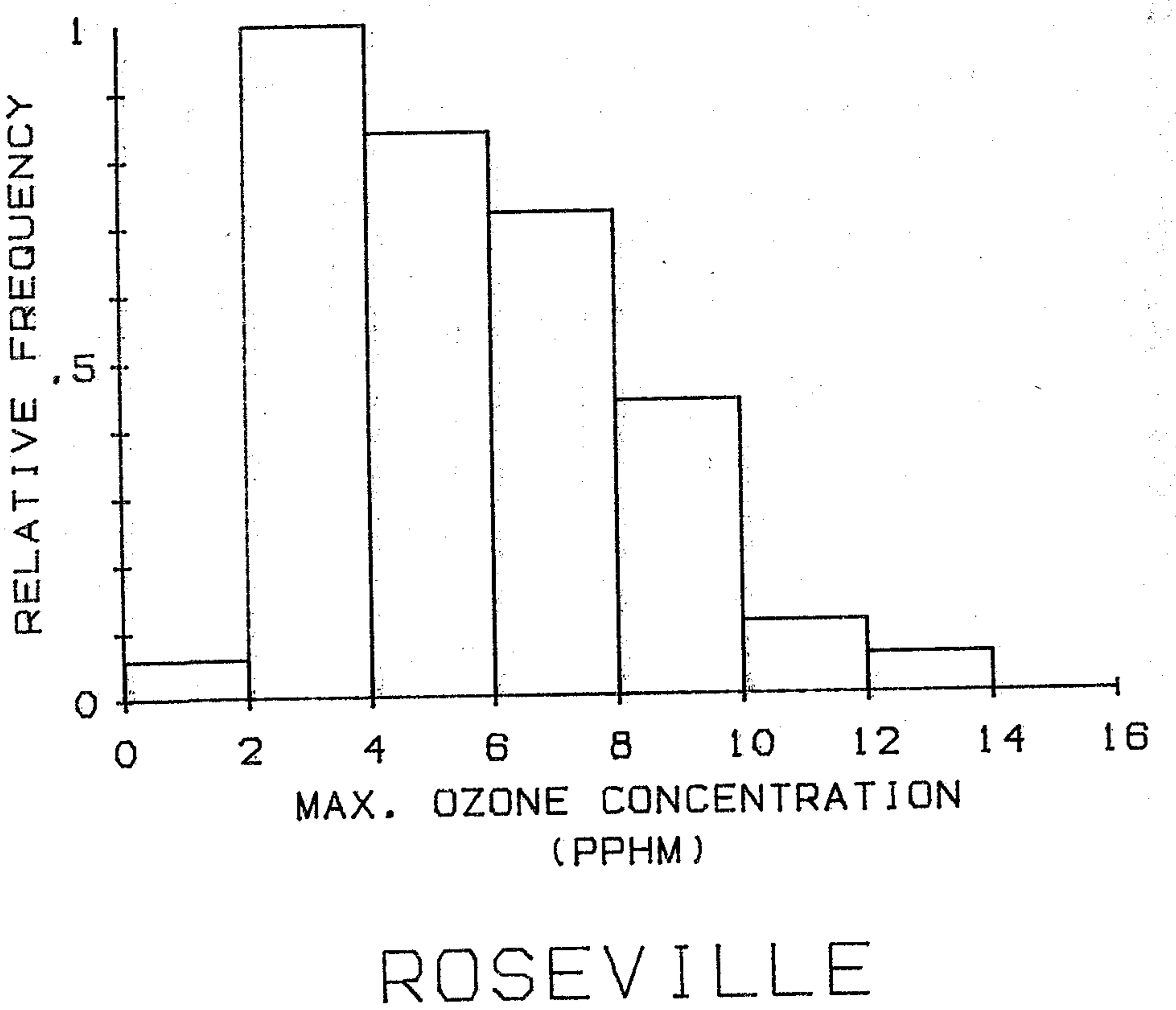
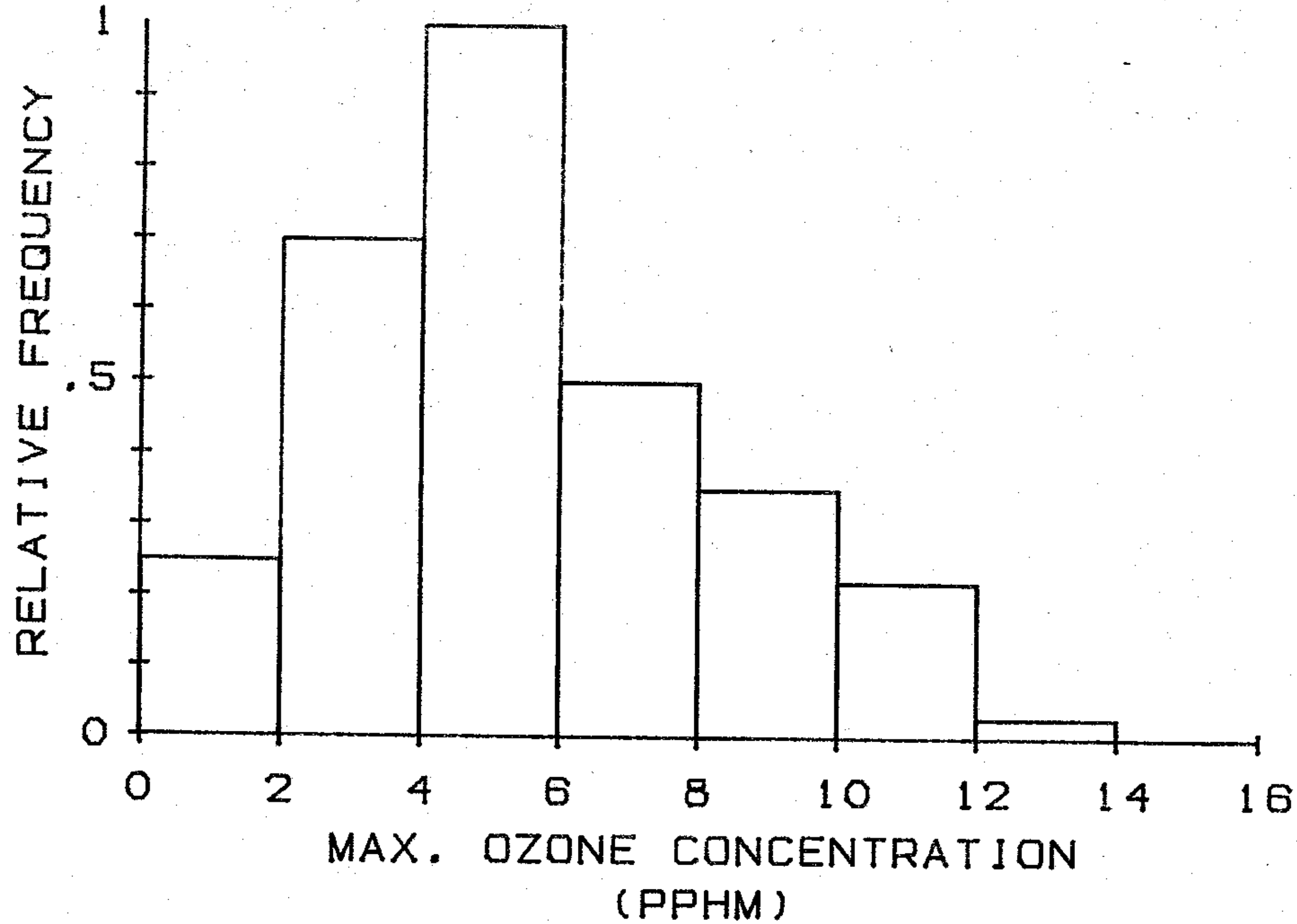


FIGURE 19

FREQUENCY OF OCCURRENCE OF MAXIMUM
OZONE CONCENTRATIONS, JUNE THROUGH SEPT., 1976



NORTHGATE

FIGURE 20

On any day it is possible that one or more monitoring locations were not in service; and since fiscal constraints usually limit the data gathering effort to that amount minimally sufficient, the completeness of the prospective data must be considered when judging the qualifications of a candidate day. This will reduce the candidate days to those week days where high ozone concentrations occurred, and the data gathering effort seems adequate for modeling purposes.

The next step is to review other agencies as possible sources of data that can be used in the modeling effort. Examples are APCDs for wind and meteorologic data, the ARB and APCD monitoring stations for ozone, carbon monoxide and other pollutants, and segments of private industry which often monitor ambient air quality for a number of public or private reasons.

Next for consideration is the quality of all the gathered data, their completeness, and their compatibility with the objectives of a regional ozone air pollution simulation program. It should now be possible to reduce the data collected during a two to three month monitoring period to those four to eight candidate days most appropriate for verifying an ozone model, and to tentatively rank them in order of desirability.

All available data for the candidate days are then entered into the AQDHS and MSDS computer files. These data include insolation, temperature, wind speed and direction at ground level and aloft, and all monitored ambient air pollutant observations.

For the Sacramento project, wind data from as many as eleven stations were put into the computer program (14) which generates wind flow field plots. A second computer program associated with the SAI airshed model interpolates the wind speeds and directions to arrive at an estimate of speed and direction for each grid square. Interpolation schemes in the SAI model were also used to distribute the measured ambient air pollutant levels throughout the Sacramento area grid cells. These data provided an estimate for pollutant concentrations between monitoring stations and also in those boundary areas of the modeling area in which no pollution monitoring devices existed. The SMOG model treats wind flow as part of the main simulation program, so no wind flow field data are available prior to the computer simulation run.

After examining the data for completeness and viewing the computer generated distribution of air pollution and meteorologic data throughout the study area, the final step in the process of selecting candidate days is to inspect the emissions data to determine if any unedited anomalous sources that might upset the verification of an ozone model were inventoried for any of the days.

ATTEMPTS TO VERIFY USING THE SAI AIRSHED MODEL (15-STEP CHEMISTRY)

The process of showing that a model fairly represents the real life air pollution conditions for a region is called, in this report, "verification". Frequently this process is referred to as "validation". Turner (15) discussed the use of these and other terms in the Journal of the Air Pollution Control Association.

Seven computer runs with the SAI airshed model were done using June 28, 1976 data.* This version of the SAI airshed model was developed in 1973 and is in the custody of Caltrans at the Teale Data Center in Sacramento. Teale is the central computer location for many State of California agencies.

Preparatory Programs

Each air pollution simulation model has its own methods for establishing concentrations throughout the gridded study area. In the case of the SAI 25x25 airshed model, there are algorithms to distribute the air pollution concentrations monitored at each station throughout the gridded study area. This is done by inputting measured ambient levels to the computer which interpolates the pollutant concentrations throughout the 625 grid cells using a $\frac{1}{r^2}$ method. The distribution is accomplished by establishing radii (r) from known points (in this case the monitoring station locations) to the grid cell centers in which the interpolated concentrations are to be determined. The output yields a regionwide field of estimated concentrations for each hour of the candidate day.

*An explanation of the reason that the SAI model used June 28, 1976 data and the SMOG model used August 24, 1976 data is in order. Three candidate days, June 28, 1976; August 24, 1976; and August 27, 1976, were selected for possible Sacramento area regional modeling. Caltrans began the modeling effort by executing the SAI model on June 28 data. A short time later MAQU ran the SMOG model on June 28 data (16). To avoid duplicating MAQU's efforts, Caltrans subsequently chose to run SMOG on August 24, 1976 data.

These concentrations can then be used for inputting boundary conditions and initial conditions to the model. Boundary condition data are necessary for each simulation hour. Although the SAI model input requires initial conditions for only the first hour of simulation, the information is in fact necessary for all simulation hours in order to check model predictions vs. measurements. The model is said to verify when the computer generated pollutant concentrations for the hours in a candidate day agree reasonably well with measured pollutant concentrations for corresponding hours.

Determination of wind speed and wind direction is required for each of the 625 grid squares. This was accomplished by examining the previously discussed wind flow fields for each hour in the candidate day and distributing the speeds and directions using a $\frac{1}{r^2}$ distribution. The temperatures were also similarly distributed by grid square from the available temperature monitoring stations. An estimate of the hourly inversion height, based on aircraft soundings, was added to these data; and wind speed, wind direction, temperature, and inversion height for each hour of each candidate day were ready for the SAI air pollution simulation program (APSP).

This information was placed on magnetic tape to be accessed simultaneously with the emission inventories.

Simulation Program

The necessary input for the APSP itself consists of run control information, among the most important of which are the grid square locations of each monitoring station;

the grid square locations of landmarks and points of interest throughout the gridded study area; explicit instructions to the program concerning the scale of the gridded study area; the chemical rate constants to be used; the intensity of the solar radiation; the units in which the concentrations are submitted; and locations, emission rates, and effective emission heights of elevated point sources.

If one wishes to use a subgrid, there are provisions in the APSP input to describe a reduced study area.

Required chemical inputs include four kinetic parameters which represent reaction rates for various kinds of reaction products. Rate constants for each of the fifteen chemical reactions in the photochemical kinetics simulation are also input. An atmospheric chemist on the staff of the ARB was consulted with regard to these values. The 15-step chemistry has been superseded by more sophisticated advances in the science, and the accuracy of values developed by the 15-step process is generally considered to be low.

The Caltrans version of the SAI model unfortunately calculates wind fields in two dimensions with no provision for changes in the vertical direction. The height of the inversion (mechanical mixing height) can, however, be varied hour by hour. The only provision for varying air quality concentrations with altitude is the "concentrations aloft" (CALOFT) algorithm. This CALOFT concentration is one input for each pollutant at a single elevation that must be held constant throughout the simulation period. Its purpose is to represent the change in pollutant level from the "box" beneath the inversion to the cleaner air above. In reality the upper air pollutant levels may vary radically from this assigned concentration.

Since the SAI model holds aloft pollutant concentrations constant for all simulation hours, several disadvantages are present. Although the concentrations aloft will almost certainly vary during the day, the model is locked into its single input which must apply to all hours. Also, any elevated emission which may occur above the mixing height (stacks, aircraft, etc.) cannot be taken into account. The onset and ebb of insolation usually cause the inversion height to rise and fall during a typical day, and the volume of the box in which ozone is being generated will change with time. Complete washing out of the inversion, which effectively takes the lid off the box and occurs most warm afternoons, is also not accounted for. It was found that ozone concentrations generated by the SAI model were generally lower than the pollutant levels needed to produce a verification. In the following paragraphs there is a discussion of some possible reasons for the failure of the SAI model with 15-step chemistry to verify.

A frequent problem in regional modeling is that the simulation day typically starts before sunrise when the ground level ozone concentration is very low or even zero. This situation affects the measured initial and boundary ozone conditions in that they, being measured on the ground, are so low that much of the ozone generated due to early morning insolation is used to bring the surface level ozone readings from near zero to that ozone concentration that would be measured were there no scavenging by ground interception and nitric oxide (NO). This layer of air with a low concentration of ozone, however, is in actuality very shallow. Results of aircraft monitoring indicate that during nighttime, above the 250 to 750 foot elevation, significant concentrations of ozone exist; and they show that these concentrations are 50-80% of the maximum concentrations of the previous day.

As an example, consider a situation where the peak ozone for the previous day was .10 ppm but the NO scavenging had depressed the next day's 0500 surface ozone reading to zero. At an elevation of 500 ft., where ground interception and NO scavenging had little or no effect, an ozone reading of .06 ppm to .08 ppm would likely be measured. If the modeler accepts the surface ozone readings for his 0500 initial and boundary values, the model must generate some .06 to .08 ppm of ozone to achieve a level that could logically (barring nighttime NO scavenging) be argued to be the proper level at which to start a simulation day. It is submitted that this poor vertical description of pollutant concentrations uses considerable ozone generation computer resources and biases the remainder of the day. The predicted ozone concentration thus does not achieve the levels it might achieve if a level of say .07 ppm were used as the initial and boundary conditions.

The mechanics of the SAI program require that the ozone void described in the preceeding paragraph exist up to the level of change prescribed for concentrations aloft. So the box is either "too full" of pollution if one ignores the observed surface readings and uses a higher ozone level or "too empty" if the observed concentrations are used.*

Thus the modeler can measure the ozone concentration at 500 ft. and use this amount for the entire box, or he must start with a surface concentration he knows to be unrealistically low. In the first case, surface ozone predictions for the early hours will not be explicit; and in the latter case, predictions in the peak ozone period will be too low due to lack of residual initial and boundary ozone throughout the box in the early hours. Our measurements during the Bakersfield monitoring flights have shown that throughout the entire box, decay of ozone overnight is about 20-50% compared to the depression of ozone near the ground in urban areas of some 80-100%.

A verification was not achieved using the SAI 25x25 airshed model. Figure 21 shows the hourly ozone levels for simulations with CALOFT at 3000 ft. and 250 ft. at the Creekside Station compared with the observed concentration for the candidate day. Examples of the SAI computer run output are shown on Figures 22 through 24. The airshed model was only able to develop at most 50% of the measured ozone levels at 1500 hours on June 28, 1976.

The cost of computation for the SAI model was approximately 1/3 of the cost to run SMOG. The necessity of the use of the SAI preparatory programs, however, brought the total costs, including labor, to near equality between the two models.

---

*Subsequent air quality models have avoided this problem.

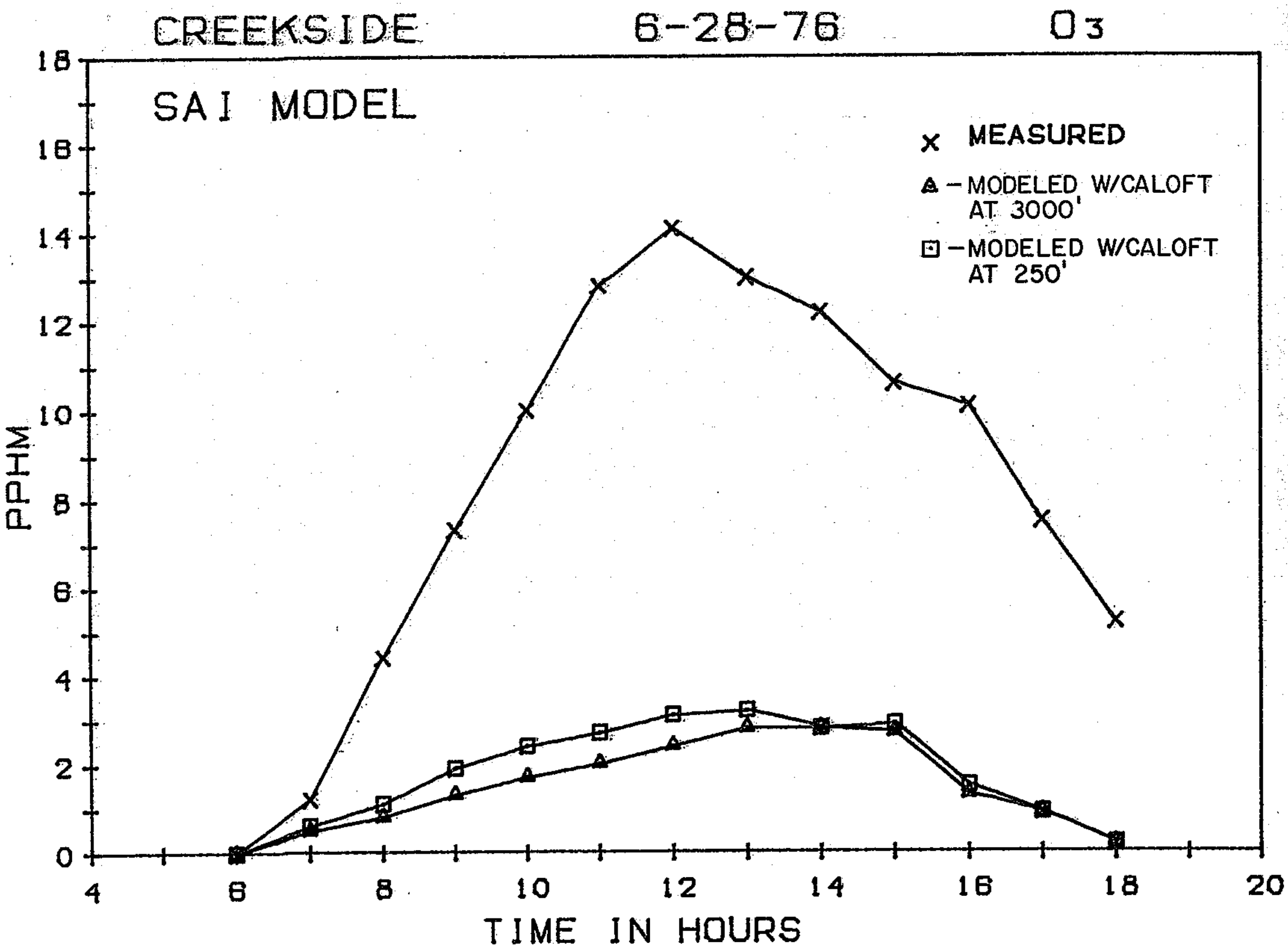

CREEKSIDE
6-28-76
O3
SAI MODEL
MEASURED
—MODELED W/CALOFT AT 3000'
—MODELED W/CALOFT AT 250'
PPHM
TIME IN HOURS
18
16
14
12
10
8
6
4
2
0
4
6
8
10
12
14
16
18
20

FIGURE 21

O_3 GROUND LEVEL CONCENTRATIONS (PPHM) AT 1500 PST ON 6-28-76
SAI MODEL PREDICTIONS W/CALOFT @ 250 FEET

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	1.0	1.1	1.4	2.0	2.9	3.7	4.2	4.2	4.0	3.7	3.6	3.7	3.9	4.1	4.2	4.3	4.3	4.3	4.3	4.3	4.4	4.3	4.1	4.1	4.4
24	1.0	1.3	1.8	2.5	3.4	4.0	4.1	3.9	3.7	3.6	3.7	3.8	4.0	4.1	4.3	4.4	4.4	4.4	4.4	4.3	4.2	3.9	3.6	3.6	3.9
																	ROSEVILLE								
23	1.2	1.6	2.1	2.9	3.7	4.0	4.0	3.7	3.6	3.6	3.7	3.9	4.0	4.2	4.3	4.3	4.3	4.1	4.1	4.0	3.8	3.5	3.3	3.3	3.5
22	1.5	1.7	2.2	3.0	3.8	4.1	4.0	3.8	3.7	3.7	3.8	3.9	4.0	4.1	4.1	4.0	3.7	3.5	3.4	3.3	3.2	3.1	3.0	3.0	3.1
																							FOLSOM LAKE		
21	1.5	1.8	2.2	3.0	3.8	4.2	4.2	4.1	3.9	3.8	3.9	3.9	3.8	3.7	3.5	3.2	2.9	2.7	2.6	2.6	2.6	2.6	2.7	2.8	3.1
20	1.5	1.7	2.2	3.0	3.9	4.4	4.4	4.3	4.1	3.9	3.8	3.6	3.4	3.1	2.7	2.5	2.4	2.2	2.2	2.1	2.2	2.3	2.6	2.9	3.3
		METRO AIRPORT																							
19	1.4	1.6	2.2	3.2	4.0	4.3	4.4	4.3	4.1	3.8	3.6	3.3	2.9	2.5	2.2	2.0	1.9	1.9	1.9	2.0	2.2	2.5	2.8	3.2	3.3
											MC CLELLAN AFB											FOLSOM			
18	1.4	1.6	2.2	3.2	3.9	4.2	4.2	4.1	3.9	3.6	3.1	2.7	2.3	2.0	1.9	1.9	2.0	2.0	2.2	2.4	2.6	2.9	3.1	3.1	3.0
17	1.4	1.8	2.5	3.3	3.8	4.0	4.0	3.9	3.6	3.1	2.5	2.1	1.9	2.0	2.1	2.2	2.2	2.3	2.5	2.7	2.9	3.1	3.1	3.0	3.0
									NORTHGATE																
16	1.6	2.2	2.9	3.3	3.6	3.8	3.8	3.6	3.2	2.6	2.0	1.7	1.7	1.9	2.2	2.4	2.6	2.7	2.8	2.8	3.0	3.2	3.4	3.6	4.0
15	2.1	2.7	3.0	3.2	3.5	3.8	3.7	3.3	2.8	2.4	2.1	1.9	1.9	2.0	2.2	2.4	2.5	2.5	2.7	3.0	3.3	3.6	4.1	4.9	6.2
										CAL EXPO															
14	2.9	2.9	3.0	3.2	3.5	3.8	3.6	3.2	2.9	2.8	2.9	3.0	3.0	2.8	2.6	2.4	2.2	2.3	2.5	2.9	3.5	4.2	5.4	6.9	8.6
							SACRAMENTO ARB																		
13	2.9	2.9	3.1	3.3	3.7	3.9	3.9	3.6	3.5	3.7	4.0	4.4	4.5	4.2	3.6	3.1	2.7	2.6	2.7	3.1	3.9	5.2	6.9	8.6	9.8
					PORT OF SACRAMENTO												MATHER AFB								
12	2.9	3.0	3.3	3.5	3.7	4.0	4.3	4.5	4.4	4.5	5.0	5.5	5.9	5.7	5.0	4.4	3.9	3.7	3.7	4.0	4.9	6.2	7.9	9.1	9.3
11	3.0	3.1	3.2	3.2	3.4	3.9	4.4	4.9	4.9	5.2	5.6	6.1	6.6	6.6	6.0	5.4	5.3	5.5	5.6	5.7	6.1	7.0	8.0	8.4	7.9
10	3.0	3.0	2.8	2.7	3.0	3.6	4.4	5.0	5.2	5.3	5.6	6.1	6.7	6.8	6.3	6.1	6.4	7.1	7.5	7.5	7.3	7.3	7.4	7.2	6.6
9	2.8	2.5	2.2	2.1	2.5	3.4	4.3	5.0	5.5	5.6	5.7	5.9	6.3	6.4	6.2	6.1	6.9	8.1	9.0	8.8	8.1	7.2	6.6	6.1	5.8
8	2.3	1.8	1.7	1.9	2.4	3.3	4.2	5.0	5.7	6.0	5.8	5.5	5.6	5.8	5.6	5.6	6.8	8.5	9.7	9.6	8.4	6.9	6.0	5.7	5.8
									MEADOWVIEW																
7	1.5	1.5	1.7	1.9	2.3	3.0	3.8	4.8	5.7	6.0	5.6	5.0	4.8	4.9	4.6	4.8	6.3	8.4	9.9	9.8	8.3	6.7	5.7	5.7	6.1
6	1.5	1.6	1.6	1.7	1.8	2.2	3.0	4.2	5.2	5.4	4.7	4.0	3.9	3.7	3.4	3.9	5.6	8.1	9.7	9.6	8.1	6.6	5.9	6.1	6.5
5	1.5	1.5	1.4	1.2	1.2	1.5	2.3	3.4	4.2	4.1	3.5	3.0	2.9	2.7	2.5	3.1	5.0	7.6	9.2	9.2	7.9	6.8	6.3	6.4	6.4
													ELK GROVE												
4	1.4	1.2	1.0	0.9	1.0	1.3	2.0	2.7	3.0	2.8	2.5	2.3	2.2	1.9	1.9	2.6	4.4	6.7	8.2	8.4	7.6	6.7	6.2	6.0	5.5
																	WILTON								
3	1.1	0.9	0.8	0.9	1.1	1.4	1.8	2.1	2.1	2.0	1.9	1.8	1.8	1.7	1.7	2.2	3.4	5.0	6.4	6.9	6.6	5.9	5.2	4.6	3.9
2	0.7	0.8	0.9	1.1	1.4	1.5	1.6	1.7	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.7	2.2	3.1	4.0	4.5	4.5	4.1	3.4	2.8	2.4
1	0.7	1.0	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.3	1.1	1.2	1.3	1.7	2.1	2.3	2.2	2.0	1.8	1.6

FIGURE 22

O_3 GROUND LEVEL CONCENTRATIONS (PPHM) AT 1500 PST ON 6-28-76
SAI MODEL PREDICTIONS W/CALOFT @ 3000 FEET

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	0.9	1.0	1.3	1.9	2.7	3.5	4.1	4.3	4.1	4.0	4.0	4.1	4.2	4.3	4.4	4.5	4.5	4.6	4.5	4.4	4.4	4.0	3.3	2.8	2.8
24	1.0	1.3	1.8	2.4	3.2	3.8	4.0	3.9	3.8	3.9	4.0	4.1	4.3	4.4	4.6	4.6	4.6	4.5	4.4	4.4	4.2	3.7	3.2	2.9	2.9
																	ROSEVILLE								
23	1.2	1.6	2.1	2.8	3.6	3.9	3.9	3.7	3.7	3.9	4.0	4.2	4.3	4.5	4.6	4.6	4.4	4.1	4.0	3.9	3.7	3.3	3.1	3.0	2.9
22	1.5	1.7	2.2	3.0	3.7	4.0	4.0	3.9	3.8	3.9	4.1	4.2	4.3	4.4	4.3	4.2	3.8	3.5	3.4	3.2	3.0	2.9	2.9	2.9	2.8
																							FOLSOM LAKE		
21	1.5	1.7	2.1	3.0	3.8	4.2	4.3	4.1	4.0	4.0	4.1	4.2	4.1	4.0	3.7	3.3	3.0	2.7	2.6	2.5	2.5	2.5	2.6	2.8	3.0
20	1.5	1.7	2.2	2.9	3.9	4.4	4.5	4.4	4.2	4.1	3.9	3.8	3.6	3.3	2.9	2.6	2.5	2.3	2.1	2.1	2.1	2.3	2.6	3.0	3.4
			METRO AIRPORT																						
19	1.4	1.6	2.2	3.1	4.0	4.4	4.5	4.4	4.2	3.9	3.6	3.3	2.9	2.5	2.2	2.1	2.0	2.0	2.0	2.0	2.2	2.5	2.9	3.3	3.5
												MC CLELLAN AFB											FOLSOM		
18	1.4	1.5	2.1	3.2	4.0	4.2	4.2	4.2	4.0	3.7	3.2	2.8	2.3	2.0	1.9	2.0	2.1	2.1	2.3	2.4	2.7	2.9	3.1	3.2	3.1
17	1.4	1.7	2.5	3.3	3.8	4.0	4.0	4.0	3.7	3.3	2.8	2.4	2.1	2.1	2.3	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3.1	3.0	3.0
									NORTHGATE																
16	1.5	2.1	3.0	3.3	3.5	3.8	3.9	3.7	3.3	2.9	2.4	2.2	2.2	2.2	2.4	2.6	2.7	2.7	2.8	2.9	3.0	3.2	3.3	3.3	3.3
15	2.1	2.8	3.1	3.2	3.5	3.7	3.7	3.3	2.8	2.6	2.4	2.4	2.3	2.4	2.3	2.4	2.5	2.5	2.8	3.1	3.4	3.7	3.9	3.8	3.7
										CAL EXPO															
14	2.9	2.9	3.0	3.2	3.6	3.7	3.4	2.9	2.6	2.6	2.7	2.8	2.8	2.7	2.6	2.5	2.4	2.6	3.0	3.5	4.0	4.3	4.3	4.1	3.8
								SACRAMENTO ARB																	
13	2.8	2.8	3.0	3.4	3.6	3.7	3.5	3.1	2.8	2.9	2.9	3.1	3.2	3.2	3.2	3.2	3.2	3.3	3.6	4.1	4.5	4.6	4.5	4.1	3.8
						PORT OF SACRAMENTO											MATHER AFB								
12	2.8	3.0	3.3	3.5	3.6	3.7	3.8	3.7	3.3	3.1	3.2	3.4	3.7	4.0	4.2	4.4	4.5	4.4	4.4	4.6	4.7	4.6	4.3	4.0	3.9
11	2.9	3.2	3.2	3.2	3.3	3.5	3.9	4.0	3.8	3.6	3.5	3.6	4.0	4.5	4.9	5.3	5.6	5.5	5.2	4.8	4.5	4.2	4.1	4.1	4.6
10	3.0	3.0	2.8	2.6	2.8	3.3	3.9	4.3	4.3	4.0	3.8	3.8	4.2	4.8	5.3	5.8	6.0	5.9	5.4	4.8	4.2	4.0	4.1	4.7	5.6
9	2.9	2.6	2.1	2.0	2.4	3.2	4.0	4.6	4.9	4.8	4.4	4.1	4.3	4.9	5.4	5.6	5.8	5.7	5.3	4.6	4.1	4.0	4.7	5.7	6.5
8	2.3	1.8	1.6	1.8	2.4	3.2	4.1	4.9	5.5	5.7	5.0	4.2	4.4	4.9	5.0	4.9	5.1	5.3	5.0	4.5	4.2	4.6	5.6	6.7	7.1
									MEADOWVIEW																
7	1.4	1.5	1.6	1.9	2.3	2.9	3.7	4.8	5.8	6.2	5.2	4.0	4.2	4.5	4.1	3.9	4.4	4.7	4.7	4.6	4.7	5.5	6.6	7.4	7.3
6	1.4	1.5	1.7	1.7	1.8	2.1	2.9	4.2	5.5	5.6	4.4	3.4	3.6	3.6	3.1	3.1	3.7	4.3	4.6	4.9	5.5	6.5	7.5	7.8	7.2
5	1.5	1.5	1.4	1.2	1.1	1.4	2.2	3.5	4.5	4.2	3.3	2.8	2.8	2.6	2.2	2.4	3.2	4.1	4.8	5.4	6.3	7.4	8.0	7.7	6.8
														ELK GROVE											
4	1.4	1.3	1.0	0.8	0.9	1.3	2.0	2.8	3.1	2.8	2.3	2.2	2.2	1.9	1.7	2.1	3.0	4.0	4.9	5.9	6.8	7.5	7.5	6.8	5.6
																		WILTON							
3	1.1	0.8	0.8	0.8	1.1	1.5	1.9	2.1	2.1	1.9	1.8	1.8	1.8	1.7	1.6	1.9	2.7	3.7	4.7	5.6	6.3	6.4	5.9	4.9	3.9
2	0.7	0.7	0.9	1.2	1.4	1.6	1.6	1.7	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.7	2.0	2.7	3.6	4.2	4.5	4.2	3.6	2.9	2.3
1	0.7	1.0	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.3	1.1	1.1	1.3	1.6	2.0	2.3	2.2	2.0	1.8	1.6

FIGURE 23

O_3 GROUND LEVEL CONCENTRATIONS (PPHM) AT 1500 PST ON 6-28-76
SAI MODEL PREDICTIONS, ZERO EMISSIONS W/CALOFT @3000 FEET

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
25	1.0	1.0	1.3	1.9	2.9	3.9	4.7	4.8	4.5	4.1	4.0	4.1	4.3	4.4	4.5	4.6	4.6	4.7	4.7	4.7	4.7	4.5	4.2	3.8	3.5
24	1.0	1.3	1.8	2.6	3.6	4.4	4.7	4.4	4.1	3.9	4.0	4.2	4.4	4.6	4.8	4.8	4.8	4.7	4.7	4.7	4.7	4.5	4.3	4.0	3.7
																	ROSEVILLE								
23	1.2	1.6	2.2	3.2	4.2	4.7	4.5	4.1	3.9	4.0	4.2	4.4	4.6	4.8	4.9	4.9	4.9	4.7	4.6	4.6	4.5	4.4	4.3	4.1	4.0
22	1.5	1.8	2.5	3.5	4.4	4.7	4.5	4.2	4.1	4.2	4.4	4.6	4.8	4.8	4.9	4.8	4.7	4.6	4.4	4.3	4.2	4.2	4.3	4.3	4.3
																							FOLSOM LAKE		
21	1.5	1.8	2.6	3.6	4.4	4.7	4.6	4.4	4.3	4.4	4.5	4.6	4.6	4.6	4.6	4.6	4.5	4.3	4.2	4.1	4.1	4.1	4.3	4.4	4.5
20	1.5	1.8	2.5	3.5	4.3	4.7	4.8	4.7	4.5	4.5	4.4	4.4	4.3	4.3	4.4	4.4	4.4	4.2	4.0	3.9	4.0	4.1	4.4	4.6	4.8
			METRO AIRPORT																						
19	1.5	1.6	2.3	3.3	4.2	4.7	4.8	4.7	4.6	4.5	4.2	4.0	4.0	4.0	4.2	4.3	4.3	4.1	4.0	3.9	4.0	4.1	4.4	4.7	4.8
											MC CLELLAN AFB											FOLSOM			
18	1.4	1.5	2.2	3.3	4.2	4.6	4.7	4.7	4.6	4.3	4.0	3.9	3.9	4.0	4.1	4.2	4.3	4.2	4.0	4.0	4.0	4.2	4.4	4.7	4.7
17	1.4	1.7	2.5	3.4	4.0	4.3	4.5	4.6	4.4	4.2	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.1	4.1	4.2	4.4	4.5	4.5
								NORTHGATE																	
16	1.5	2.1	3.0	3.5	3.8	4.2	4.4	4.4	4.1	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.4	4.3	4.3	4.3	4.2
15	2.1	2.8	3.2	3.5	3.8	4.2	4.3	4.1	3.9	4.0	4.1	4.1	4.0	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.6	4.5	4.3	4.1	3.9
										CAL EXPO															
14	2.9	3.0	3.2	3.5	3.9	4.1	4.1	3.9	3.8	3.9	4.0	4.0	4.0	3.9	4.0	4.1	4.2	4.3	4.5	4.7	4.7	4.5	4.2	3.9	3.8
							SACRAMENTO ARB																		
13	2.9	3.0	3.3	3.6	3.9	4.0	3.9	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.3	4.4	4.5	4.7	4.7	4.5	4.1	3.9	3.8
					PORT OF SACRAMENTO											MATHER AFB									
12	2.9	3.1	3.4	3.6	3.7	3.8	3.9	4.1	4.1	4.1	4.0	4.1	4.3	4.5	4.6	4.6	4.6	4.7	4.7	4.6	4.5	4.3	4.1	4.0	4.2
11	2.9	3.2	3.3	3.3	3.3	3.6	4.0	4.3	4.4	4.3	4.1	4.1	4.5	4.7	4.9	5.0	5.1	5.1	4.9	4.6	4.4	4.3	4.3	4.5	5.0
10	3.0	3.0	2.9	2.7	2.8	3.4	4.1	4.6	4.7	4.6	4.4	4.3	4.5	4.9	5.1	5.2	5.3	5.2	5.0	4.7	4.5	4.4	4.7	5.2	5.8
9	2.9	2.6	2.1	2.0	2.4	3.3	4.1	4.8	5.1	5.1	4.8	4.5	4.6	5.0	5.1	5.1	5.2	5.2	5.1	4.8	4.7	4.9	5.4	6.0	6.4
8	2.3	1.8	1.6	1.8	2.4	3.3	4.2	5.0	5.6	5.9	5.3	4.5	4.6	4.9	4.7	4.5	4.8	5.0	5.1	5.0	5.1	5.5	6.2	6.7	6.8
									MEADOWVIEW																
7	1.5	1.5	1.6	1.9	2.3	2.9	3.8	4.8	5.9	6.3	5.4	4.2	4.3	4.5	4.1	3.9	4.3	4.9	5.2	5.4	5.7	6.3	6.9	7.2	7.0
6	1.5	1.6	1.7	1.7	1.8	2.1	2.9	4.4	5.7	5.8	4.5	3.6	3.7	3.8	3.3	3.2	4.0	4.8	5.3	5.8	6.4	7.1	7.6	7.5	7.0
5	1.5	1.5	1.5	1.2	1.1	1.4	2.3	3.7	4.6	4.3	3.3	2.8	3.0	3.0	2.6	2.8	3.7	4.7	5.5	6.3	7.1	7.8	8.0	7.5	6.7
													ELK GROVE												
4	1.4	1.3	1.0	0.8	0.9	1.3	2.1	2.8	3.1	2.9	2.4	2.2	2.4	2.3	2.1	2.4	3.4	4.5	5.6	6.6	7.5	7.9	7.6	6.7	5.6
																		WILTON							
3	1.1	0.9	0.8	0.8	1.1	1.5	1.9	2.1	2.1	2.0	1.9	1.8	1.9	1.9	1.8	2.1	3.0	4.1	5.3	6.3	6.8	6.6	5.9	4.8	3.8
2	0.7	0.7	0.9	1.2	1.4	1.6	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.8	2.2	2.9	3.8	4.4	4.6	4.3	3.6	2.9	2.3
1	0.7	1.0	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.3	1.2	1.2	1.3	1.7	2.1	2.3	2.2	2.0	1.8	1.6

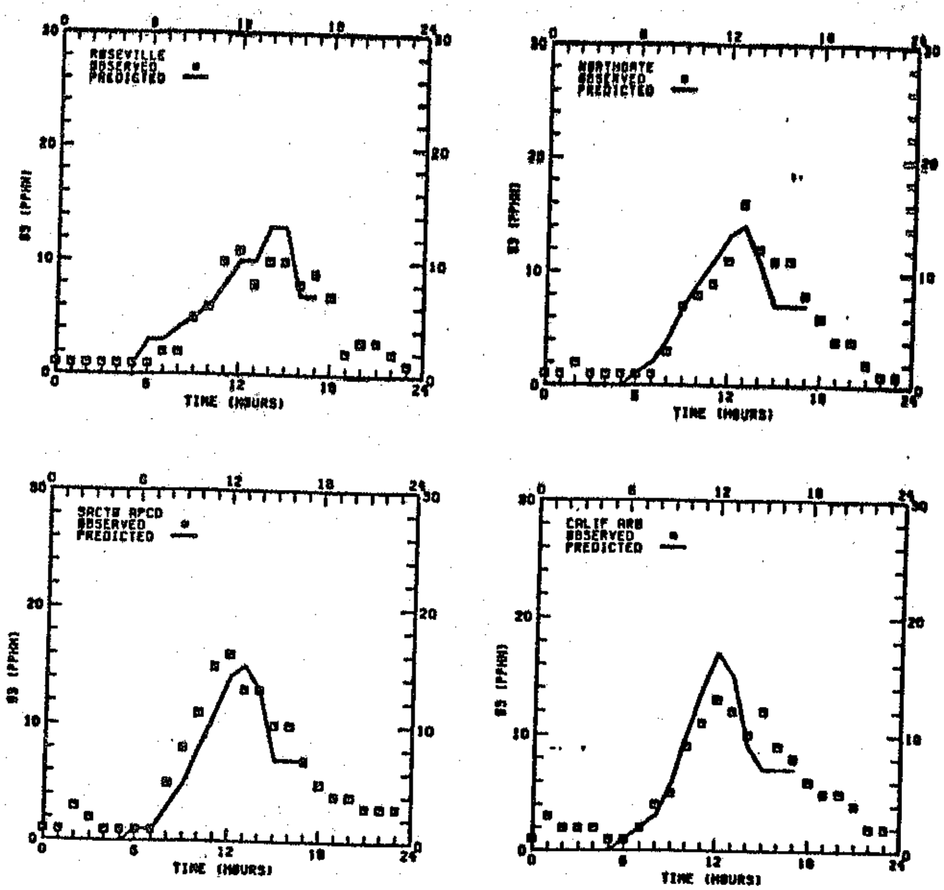
FIGURE 24

SACRAMENTO MODELING BY SAI USING ADVANCED MODELS

As regional modeling matured and the short-comings of the SAI 15-step airshed model became obvious, SAI in San Rafael developed a more advanced airshed model. In a series of reports (17), SAI reported on their modeling activities including those for the Sacramento area. Pages 2-7 through 2-17 of Volume 1 of those reports contain a discussion of the evolution of the advanced SAI model complete with reasons for revising the 15-step chemistry model.

The Sacramento data base was made available to SAI in San Rafael by the Federal Highway Administration's research office; and working under a research grant from that office, SAI simulated the air quality in the Sacramento area for June 28 and August 24, 1976, using their advanced model with 38-step carbon-bond-mechanism chemistry. Chapter 4 of Volume 1 of their report series is a 52 page discussion of performance of their 38-step chemistry model for Sacramento. Figures 25 through 30 are reproduced from that report to provide comparisons of the SAI advanced model work with the results from the earlier SAI 15-step chemistry model and the SMOG model. They show that the advanced SAI model yielded a close estimate of the observed ozone concentrations for the June 28 and August 24 candidate days.

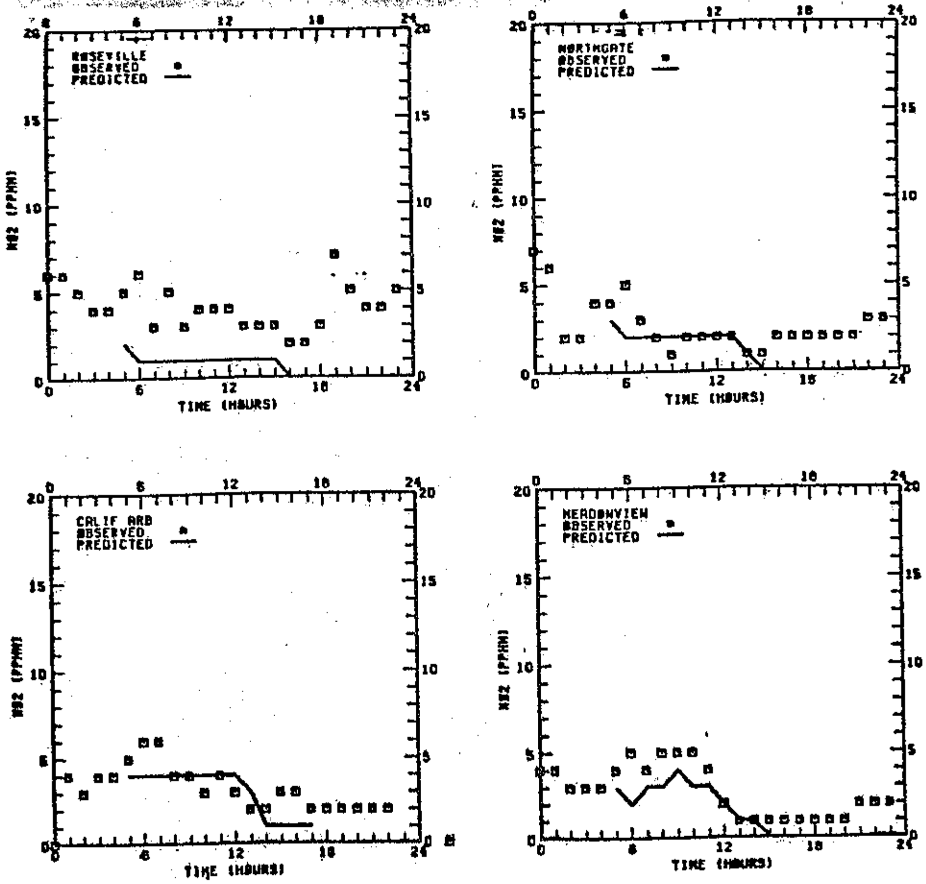
When viewing figures that show observed concentrations in Sacramento, the reader should be advised that observed concentrations of 0.1 parts per million or 0.01 parts per million can actually be concentrations of zero. The 1973 SAI model was not able to distinguish between "station not operating" and "station reading zero". Therefore, whenever



PREDICTED AND OBSERVED OZONE CONCENTRATIONS FOR 28 JUNE 1976 USING ADVANCED SAI MODEL - SACRAMENTO

(From Reference #17)

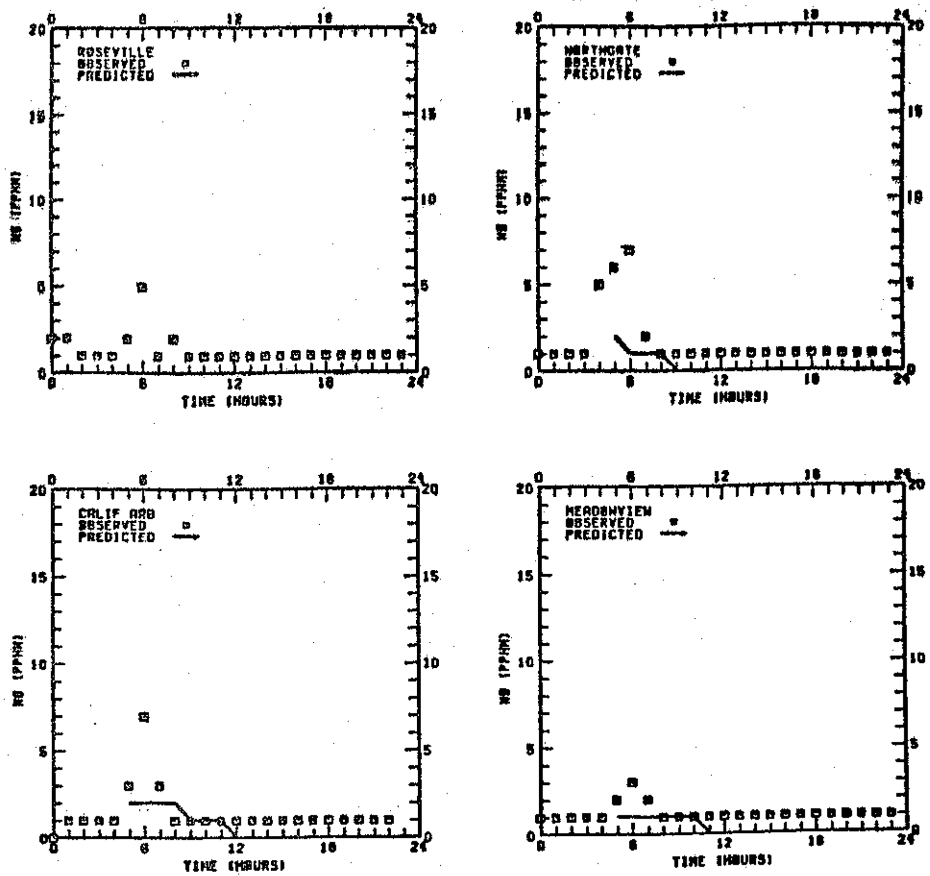
FIGURE 25



PREDICTED AND OBSERVED NO_2 CONCENTRATIONS FOR 28 JUNE 1976 USING ADVANCED SAI MODEL - SACRAMENTO

(From Reference #17)

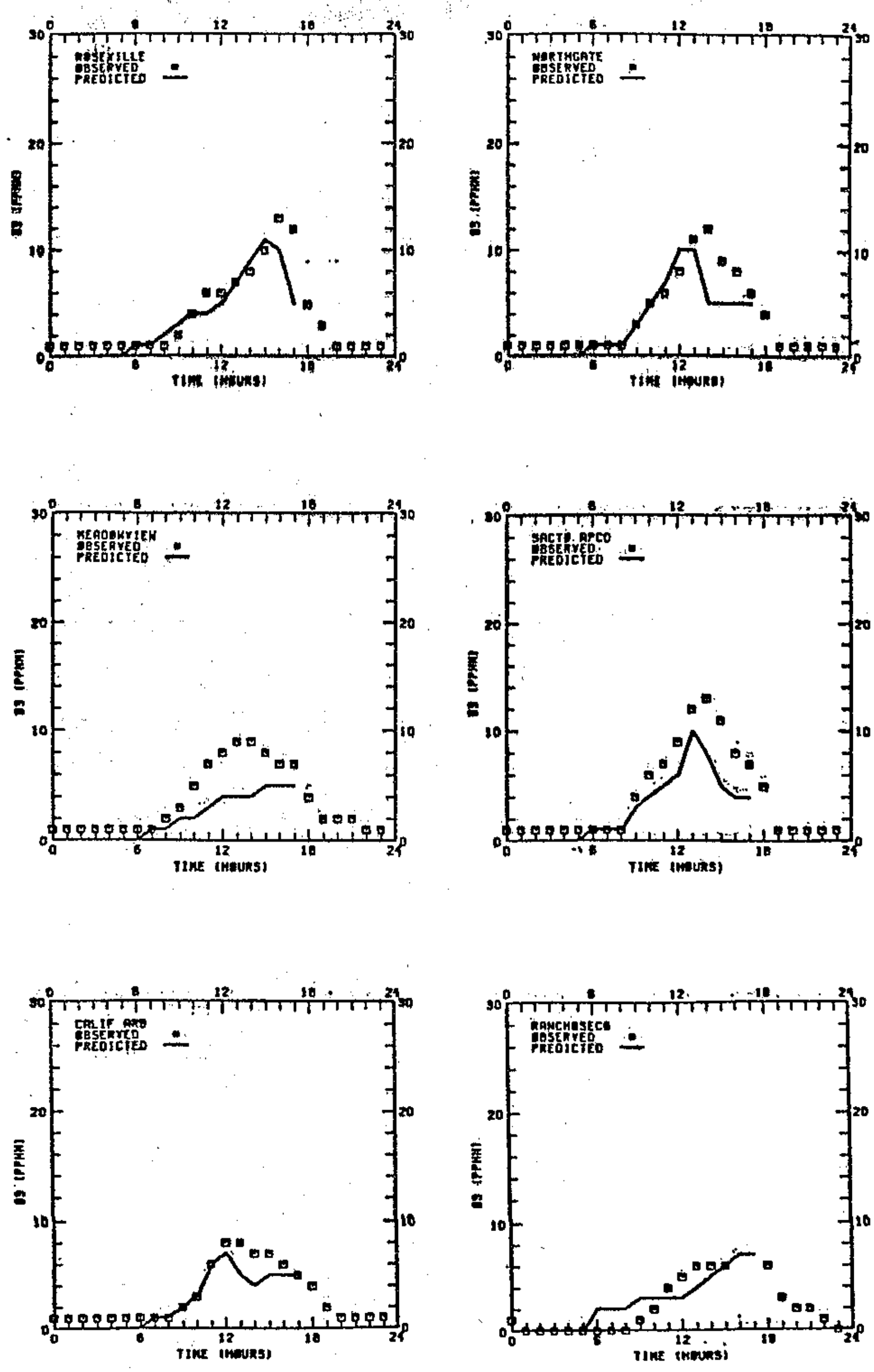
FIGURE 26



PREDICTED AND OBSERVED NO CONCENTRATIONS FOR 28 JUNE 1976 USING ADVANCED SAI MODEL - SACRAMENTO

(From Reference #17)

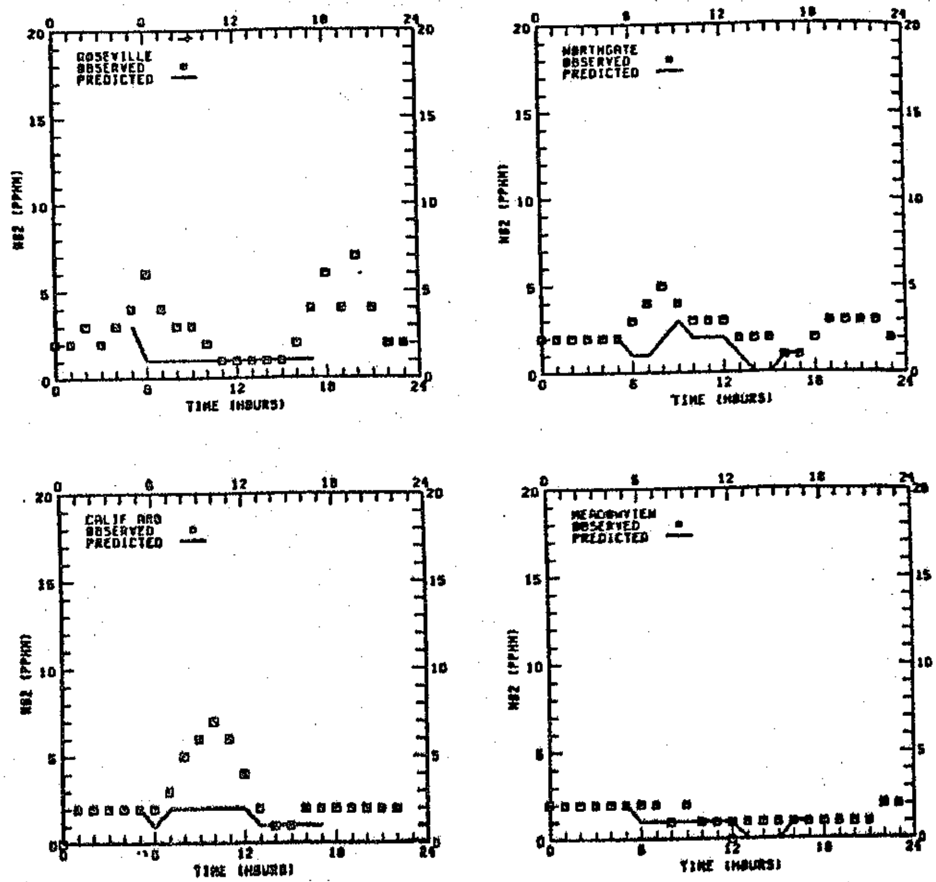
FIGURE 27



PREDICTED AND OBSERVED OZONE CONCENTRATIONS FOR 24 AUGUST 1976 USING ADVANCED SAI MODEL - SACRAMENTO

(From Reference #17)

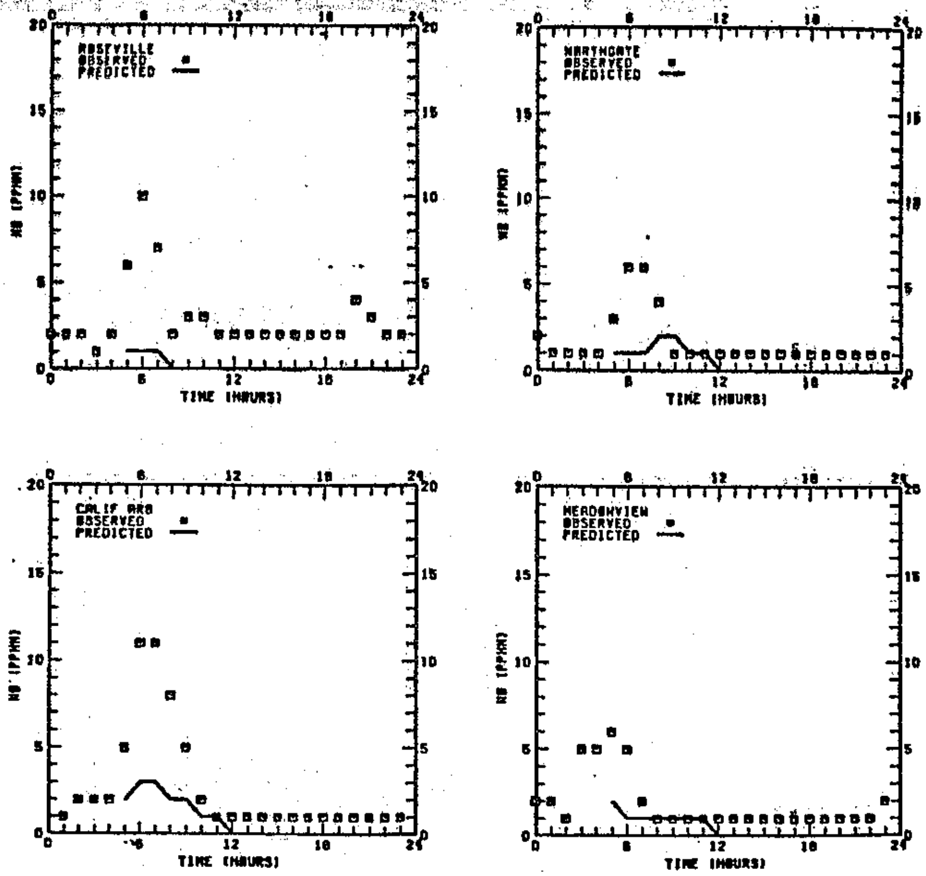
FIGURE 28



PREDICTED AND OBSERVED NO_2 CONCENTRATIONS FOR 24 AUGUST 1976 USING ADVANCED SAI MODEL - SACRAMENTO

(From Reference #17)

FIGURE 29



PREDICTED AND OBSERVED NO CONCENTRATIONS
FOR 24 AUGUST 1976 USING ADVANCED SAI MODEL -
SACRAMENTO

(From Reference #17)

FIGURE 30

the station was operating and reading zero, we had to assign a minimum pollutant concentration level to that station. Thus, carbon monoxide was assigned a minimum concentration of 0.1 ppm; while ozone, NO_x, and hydrocarbons were assigned a minimum of .01 ppm.

SMOG MODEL VERIFICATION

The SMOG model (Simulation Model for Ozone Generation) was developed from the IMPACT model by Science Applications, Inc. of Westlake Village, California. The SMOG model is public, and maintained by the ARB. MAQU used the SMOG model for an ozone simulation using the data of June 28, 1976, and were successful in achieving a model verification (16). The Air Quality Unit of the Caltrans Laboratory used the same model for ozone using the data base for August 24, 1976.

Comparison of Model Input Requirements

The SMOG model differs from the SAI model in many respects. A major fundamental difference is that the SMOG model includes data preparation programs in the simulation program. The SMOG model's simulation run includes grid cell distribution of wind data, air quality data, diffusivity data, and upper cell concentrations, while these are established by preparatory programs for the SAI model. The SMOG model allows the user a range of choices for data preparation depending on the needs of the simulation.

The SMOG model has a 39-step chemistry as opposed to the 15-step chemistry of the 1973 version of the SAI model.

The SAI model has one vertical layer. This locks the aloft concentrations into a single reading for each pollutant for the entire simulation period. The SMOG model user may choose any reasonable number of equally thick vertical layers, each of which may initially have separate pollutant concentrations which change throughout the simulation due to chemical transformations, transport, and diffusion. The SMOG model user must input background (starting) concentrations for each vertical layer. The number of vertical layers is generally determined by assessing the money available for computation time (more cells means higher costs), the user's knowledge of aloft pollutant levels, and the height of the mixing level.

Perhaps the most significant difference when considering the abilities of the models to correctly predict ozone concentrations is the treatment of reactive hydrocarbons. The SAI model uses the measured levels of total hydrocarbons and reactive hydrocarbons. The SMOG model does not use total hydrocarbons but requires the concentrations of four lumped species of reactive hydrocarbons: 1) paraffins, 2) aromatics, 3) olefins, and 4) aldehydes.

An important set of air quality inputs common to both models are the boundary conditions. This information is necessary to enable the computer to quantify the pollutant concentrations in air advected into the gridded study area.

Table 4 is a summary of the major departures of the models used on the project.

Table 4
Model Comparisons

	SAI 15-Step Chemistry	SMOG Model
Gridded Area	Any configuration without a void surrounded by active cells (no doughnut shapes)	Rectangular area required - any length at sides
Wind Flow Fields	Preparatory program	Internally generated with ozone simulation
Chemistry	15-step	39-step
Vertical Resolution	Mixing depth & CALOFT only	User designates number of vertical cells with each cell taking its own properties
Preparatory Programs	Air quality, wind, mixing depth	None
Hydrocarbon Treatment	Considers total & reactive - no species	Reactive only - 4 lumped species

Development of the Input Values

As the modeler gains experience, he is able to estimate relatively correct concentrations for various locations on the surface in the gridded study area and in the elevated layers even in the absence of direct measurements. The following phenomena help the modeler. In the case of ozone, direct ground interception and NO emissions from motor vehicles tend to scavenge the ozone at night along the surface of the earth. On the central valley floor in urban areas this ozone depression is perhaps 80-100% complete. Analysis of the data taken during our airplane flights in the southern San Joaquin Valley with an ozone monitoring device on board enabled our personnel to estimate the ozone profile in Sacramento up to the maximum vertical cell elevation of 1,000 meters. This was done by examining the Sacramento ground concentrations over a two-day period and determining night and morning surface and aloft concentrations based on those measured in the Bakersfield region under similar conditions. Specifically, for the August 24 candidate day, the ground level ozone initial conditions were fixed at .01 ppm while the concentrations for the second and third vertical cells were each fixed at .05 ppm.

Another problem is determining the correct ambient concentrations of reactive hydrocarbons. It is generally agreed that measurement of ambient reactive hydrocarbons is the weakest link in the state of the air pollution monitoring science, and the measurements made in the Sacramento region would tend to support this idea. For example, at the three monitoring stations in the Sacramento region during the critical 6:00 a.m. to 9:00 a.m. period, the reactive hydrocarbon concentrations observed varied from .01 ppm to .30 ppm, with the third reading lying approximately midway between the other two. These readings vary too greatly to arrive at a sensible average.

As an alternative to using the directly monitored reactive hydrocarbon readings, it was decided to use an equation developed by the ARB for relating total hydrocarbon (THC) and reactive hydrocarbon (RHC) concentrations in the Los Angeles Basin. The equation is

$$\text{THC} = 1.55\ \text{RHC} + 1.35 \qquad \text{(Eq. 1)}$$

The monitored total hydrocarbon readings are recognized to be reasonably accurate since they are more easily distinguished than reactive hydrocarbons in a sample of air.

After determining the estimated reactive hydrocarbon concentration from Equation 1, a set of hydrocarbon splits developed by the ARB was used to break down the reactive hydrocarbons developed from the equation into the lumped species to be used by the SMOG model.*

In the absence of any measurements of concentrations of total or reactive hydrocarbons for the upper four vertical cells, concentration assignments were based on the amount of pollutant that atmospheric chemists on the ARB staff said were necessary to produce ozone concentrations determined to be correct for that altitude. As can be seen in Table 6, the concentrations assigned were 50% to 75% of those concentrations calculated for the ground level cell.

There is another way to view the situation, one which would have resulted in a lower hydrocarbon assignment for the upper level cells. In this alternate scenario, the modelers could have assumed that the upper level ozone was advected from nearer the surface and was simply residing there without accompanying significant concentrations of hydrocarbons and NO_x.

*Hydrocarbon Splits

1.	Olefins	13%	with 2.9 average carbon atoms/molecule
2.	Aromatics	26%	with 7.0 average carbon atoms/molecule
3.	Paraffins	60%	with 3.75 average carbon atoms/molecule
4.	Aldehydes	1%	with 1.73 average carbon atoms/molecule

In the case of oxides of nitrogen, the observed surface concentrations from our field monitoring were used. NO concentrations close to zero were taken when high concentrations of ozone were present. Concentrations of NO_x aloft were based on the steady state equilibrium equation $O_3 = \frac{K_1}{K_3} \frac{NO_2}{NO}$ where K_1 is a function of the solar insolation, and K_3 = 20.8 (a constant).

Attached in Appendix C to this report are the SMOG input data for the "two-thirds hydrocarbon" level run of August 24, 1976. The SMOG model user's manual prepared for the ARB is available through that agency (5)

Other necessary inputs were taken from various sources. The elevation of the terrain was taken from U.S. Geologic Survey quad sheets; the surface roughness was estimated by air quality engineers of Caltrans and the ARB; the solar intensity was measured at the Transportation Laboratory, and these data were checked for reasonableness by output from computer programs that can develop the solar intensity for any latitude in the northern hemisphere for a given month and day; the air pressure and the concentration of water vapor were taken from U.S. Weather Bureau records and the hourly temperatures were averaged from various Caltrans meteorologic station data.

The initial ambient concentrations are presented at the start of the simulation run. For purposes of representing the initial concentrations with improved resolution, it was decided to split the Sacramento gridded area into three parts. In general, the three sections were the southern half, the northwestern quarter, and the northeastern quarter. Thus, there were three sets of start-time concentrations submitted to the computer at the opening of the simulation day.

The boundary concentrations are basically similar to initial concentrations, however, boundary concentrations are necessary for each hour of ozone simulation. There is a set (five vertical layers thick) of boundary concentrations for each cell along the four sides of the gridded area plus a set of concentrations for the lid of the simulation box.

The boundary conditions at the surface are taken from pollutant concentration data inside and outside the study area that are most adjacent to the affected grid cells. For example, the pollutant concentrations at Davis were considered during the establishment of the western boundary concentrations, and concentrations in the delta area influenced the southerly boundary concentration assignments.

The stability class profiles for each hour were developed taking into consideration cloud cover, solar elevation, and surface wind speeds. It was necessary to extrapolate these data to the upper cells due to the absence of pilot balloon readings on candidate days. The vertical temperature profiles were based on data from aircraft temperature flights.

Surface wind and initial concentration inputs to the SMOG model for the August 24 candidate day are shown in Tables 5 and 6.

SMOG SIMULATION PROGRAM OUTPUT

The program yields windflow fields for each hour of simulation. Vectors are calculated for each vertical cell.

TABLE 5

Surface Wind Data
August 24, 1976

	Del Campo High Cell (16,18)		Rio Linda Cell (10,19)		Roseville Met Cell (18,24)	
Time (PST)	Wind Speed (m/sec)	Direction (Az)	Wind Speed (m/sec)	Direction (Az)	Wind Speed (m/sec)	Direction (Az)
06-07	0.9	150	3.1	150	1.3	180
07-08	0.9	120	2.2	130	1.3	150
08-09	1.3	140	2.7	120	1.8	150
09-10	1.3	180	2.7	120	1.3	210
10-11	1.3	240	2.2	130	1.8	270
11-12	1.3	290	0.9	150	2.2	30
12-13	1.3	270	1.3	220	1.8	320
13-14	1.8	270	1.8	210	2.2	240
14-15	2.2	210	1.3	210	2.2	260
15-16	2.2	260	1.3	170	2.2	210
16-17	1.8	250	1.3	130	1.8	200
17-18	2.2	210	2.2	130	2.2	210
18-19	2.7	210	2.2	150	2.2	220

TABLE 5
(Continued)

Surface Wind Data
August 24, 1976

Time (PST)	Meadowview CHP Cell (9,8) Wind Speed (m/sec)	Direction (Az)	TransLab Cell (11,12) Wind Speed (m/sec)	Direction (Az)	Wilton Cell (18,3) Wind Speed (m/sec)	Direction (Az)
06-07	1.8	150	0.9	150	2.2	150
07-08	1.3	180	1.3	120	1.8	150
08-09	1.3	150	1.3	90	1.3	120
09-10	1.8	180	1.3	120	1.8	90
10-11	0.9	300	1.3	180	1.8	80
11-12	1.8	240	1.3	180	0.9	130
12-13	2.2	240	1.3	240	0.9	150
13-14	2.2	270	1.8	240	1.8	210
14-15	2.7	240	1.8	210	1.3	200
15-16	2.7	210	1.8	210	1.3	170
16-17	2.7	210	2.2	210	2.2	210
17-18	3.1	210	1.8	210	1.8	240
18-19	5.4	220	3.6	210	2.2	240

TABLE 5
(Continued)

Surface Wind Data
August 24, 1976

Time (PST)	Rancho Murieta Cell (25,10) Wind Speed (m/sec)	Rancho Murieta Cell (25,10) Direction (Az)	Rancho Seco Cell (25,1) Wind Speed (m/sec)	Rancho Seco Cell (25,1) Direction (Az)	Yolo Causeway Cell (2,12) Wind Speed (m/sec)	Yolo Causeway Cell (2,12) Direction (Az)
06-07	1.8	150	0.4	162	1.8	120
07-08	1.3	150	0.0	162	1.3	120
08-09	1.3	170	0.4	280	0.9	100
09-10	1.3	180	0.9	270	0.9	120
10-11	1.8	210	0.9	300	0.9	150
11-12	2.2	220	0.9	260	0.9	180
12-13	2.2	240	0.9	290	1.3	150
13-14	3.1	240	1.3	290	1.3	210
14-15	3.1	220	1.3	280	1.8	150
15-16	3.6	240	1.3	280	2.2	160
16-17	3.1	220	1.8	290	2.7	200
17-18	4.0	210	1.8	280	4.5	210
18-19	4.0	210	1.3	270	3.6	210

TABLE 5
(Continued)

Surface Wind Data
August 24, 1976

Time (PST)	Deep Water Channel Cell (4,10) Wind Speed (m/sec)	Deep Water Channel Cell (4,10) Direction (Az)	New CHP Academy Cell (5,14) Wind Speed (m/sec)	New CHP Academy Cell (5,14) Direction (Az)
06-07	1.3	160	1.3	140
07-08	1.3	160	1.3	115
08-09	1.3	170	1.3	90
09-10	1.3	140	1.3	90
10-11	0.9	150	1.3	200
11-12	0.9	240	1.8	250
12-13	1.3	270	2.2	260
13-14	1.8	270	2.2	270
14-15	1.8	240	2.7	230
15-16	1.8	240	2.2	230
16-17	2.2	240	4.9	220
17-18	2.7	230	4.5	220
18-19	4.5	240	4.5	220

TABLE 6

Initial Concentrations (PPM)

0600 hrs. August 24, 1976

Meadowview

Southern Grid (J = 1 through 13)

	NO_2	NO	O_3	Olefins	Aromatics	Paraffins	Aldehydes
Surface - 200m	.04	.08	.01	.10	.009	.040	.002
200m - 400m	.006	.001	.05	.007	.007	.025	.001
400m - 600m	.006	.001	.05	.007	.007	.025	.001
600m - 800m	.001	.001	.01	.007	.007	.025	.001
800m - 1000m	.001	.001	.01	.007	.007	.025	.001

Northgate

Northwest Grid (J = 14 through 25, I = 1 through 13)

	NO_2	NO	O_3	Olefins	Aromatics	Paraffins	Aldehydes
Surface - 200m	.02	.07	.01	.020	.017	.072	.003
200m - 400m	.006	.001	.05	.014	.011	.050	.002
400m - 600m	.006	.001	.05	.014	.011	.050	.002
600m - 800m	.001	.001	.01	.014	.011	.050	.002
800m - 1000m	.001	.001	.01	.014	.011	.050	.002

Roseville

Northeast Grid (J = 14 through 25, I = 14 through 25)

	NO_2	NO	O_3	Olefins	Aromatics	Paraffins	Aldehydes
Surface - 200m	.03	.06	.01	.016	.013	.060	.002
200m - 400m	.006	.001	.05	.011	.009	.040	.002
400m - 600m	.006	.001	.05	.011	.009	.040	.002
600m - 800m	.001	.001	.01	.011	.009	.040	.002
800m - 1000m	.001	.001	.01	.011	.009	.040	.002

Diffusivities are calculated for each vertical cell; and the atmospheric chemistry program, of course, computes ozone, NO, NO_2 and four lumped-species hydrocarbon concentrations for each grid cell. This information is output in two ways; one is an instantaneous concentration on the hour, and the second is the average concentration for each of these pollutants throughout the hour. At the user's option, this information can be computed and printed out for other selected periods of time, for example every three hours, every six hours, etc. The Sacramento study was output on a one hour basis.

The amount of computer expense is largely based on the size and complexity of the modeling volume. For the Sacramento SMOG simulation, five vertical cells of 200 meters height each were used. This vertical dimension, along with the 25 north-south cells and the 25 east-west cells, resulted in a central processing unit (CPU) time of approximately 1-1/2 hours. So the Sacramento SMOG model required 7 to 8 minutes of CPU time per hour of simulation time for a total cost of approximately $800 per daily simulation run.

SMOG MODEL SIMULATION RUNS

There were a total of six simulation runs performed with the SMOG model. Five of these runs started with initial conditions as measured on actual candidate days, and one was made with initial conditions simulating a typical clean-air day for the Sacramento region. The surface ozone and oxides of nitrogen levels for the five runs that simulated candidate day conditions were input directly from data taken by the monitoring equipment. As stated previously, however, development of the reactive hydrocarbon input was more complex. To rigorously follow monitored reactive hydrocarbon levels, the input readings would have been Roseville .30 ppm, Northgate .15 ppm and Meadowview .01 ppm. Clearly, these readings are not consistent nor are any of them necessarily correct; and an average of the three would not have any rational sense. Given these observations, and the fact that both equipment manufacturers and scholars agree that reactive hydrocarbon readings are questionable at best, the previously described method for estimating reactive hydrocarbon concentrations (Equation 1) was used. This equation gave the following reactive hydrocarbon levels, Roseville .68 ppm; Northgate .55 ppm; and Meadowview .35 ppm. Using this as a basis, reactive hydrocarbon levels equivalent to the Meadowview .35 ppm reading were assigned to the lower half of the study area. The Northgate .55 ppm level was assigned to the northwest quarter of the study region, and the Roseville .68 ppm level was assigned to the northeast quarter of the study area.

The first simulation using these reactive hydrocarbon levels, the so-called "full" hydrocarbon levels, resulted in a near verification. The afternoon ozone readings were consistent with the observed readings. In the simulated morning, however, the ozone levels developed by the SMOG model rose more rapidly than did the ozone levels actually observed by the monitoring stations. The ARB modelers had warned that this was a probability, because the hydrocarbon levels used were, in their opinion, somewhat high. For the next two SMOG simulation runs, the "full" hydrocarbon levels were cut by one-third to yield what we called a "two-thirds of full" hydrocarbon level and by two-thirds to yield a "one-third of full" hydrocarbon level. As expected, this slowed down the rate of ozone generation in the morning and resulted in what was considered to be a verification. The verification point lies between the "full" hydrocarbon level and the "two-thirds" hydrocarbon level, and analyses indicate that perhaps 80% of "full" hydrocarbon level is the point at which the model would simulate most closely the observed ozone generation on the August 24, 1976, candidate day.

On the fourth simulation run using SMOG, no boundary values were input to the computer. The reason this run was made is that it is conceivable that the verification was achieved because the pollutant levels input for boundary conditions were close enough to the verification level that simply advecting air into the study area would bring it to an ozone level that could be considered a verification. Although simple inspection of the first three simulation runs indicated that this was probably not the case, to evaluate this possibility, and to test the effect of not "dirtying" the air advected into the study area, a "no boundary condition" run was made. The results of this run showed that the boundary conditions had a limited but favorable effect on the levels generated by the model; and although a verification was not achieved, the ozone levels were erratic but generally greater than 75% of those observed on the candidate day.

The fifth simulation was made without any stationary or mobile emissions contributing to the pollutant concentrations within the Sacramento region. That is to say, the computer was informed that all emissions in the Sacramento area had ceased, and the computer was asked what level of ozone would be generated using only the effects of pollutants advected from other areas (as represented by the boundary concentrations) and those pollutant levels determined to be the ambient concentrations at 6:00 a.m. This trial, which was called a "zero emissions" run, was to evaluate the sensitivity of the model with regard to emissions and also to test the potential for improvement in the air quality of the Sacramento region when no pollutant emissions are being released. It was found that the result of running the SMOG model with no emissions was to decrease the ozone prediction by approximately 10% or .01 ppm. Ranzieri, Allen, and Tilden (16) found that a decrease in hydrocarbon emissions of 30% or a decrease in NO_x emissions of 30% resulted in no change on the average in SMOG model generated ozone concentrations from intra-day simulations.

Upon viewing these results, one's first reaction might be that no strategy involving control of emissions would aid in attaining air quality standards in the Sacramento region and that this simulation run means that ozone is something that is going to have to be lived with as long as Northern California contains automobiles and industry. On the other hand, since the meteorology of August 24, 1976, in the Sacramento area is known to be for a high ozone day, and the initial conditions were taken at 6:00 a.m. on a high ozone day, it was decided to analyze the probability that this candidate day was an air quality day not sensitive to emissions. That is to say that the ozone concentration would be elevated without regard to any emissions due to the high pollutant levels carried over from the earlier day and the contaminated air being advected into the study area from adjoining regions. It was hypothesized that this existing air had such high pollutant concentrations that pollutant decay over the thirteen hour simulation time was sufficiently low that the effect of having zero emissions was only slightly noticeable in that period of time.

To consider this possibility, a sixth simulation run was performed using the meteorology for a high pollutant day but using initial and boundary air quality conditions for a so-called clean air day. The oxides of nitrogen were taken down to .03 ppm NO_2 and .01 ppm NO, the initial ozone concentration was reduced to .01 ppm at the surface and .04 ppm aloft, and the reactive hydrocarbon level was lowered from the order of .10 ppm to .68 ppm (aloft to surface) to a uniform .05 ppm. The model output showed ozone levels to .05 ppm which is approximately one-half of those achieved in each of the other five simulation runs and also about one-half of the maximum observed ozone concentration for the day.

The results of this simulation run indicate that additional sensitivity trials with the SMOG model will likely show that planned or mandated emission controls can be effective in controlling ozone concentrations within a region when naturally clean air is present and low transport occurs. The SMOG model runs, at the same time, say that emergency emission controls within a region seem to be relatively ineffective if the controls are instituted after a pollution episode is underway within the region.

A further step would be to compute over one or two nights with clean air initial conditions, average emissions, and meteorology for high ozone conditions to see if the level of ozone concentration were further enhanced. Unfortunately, funding for this work is not available at present.

Figures 31 through 46 show the relationships between measured vs. modeled air pollutant values at monitoring stations in the region. The model-predicted and measured ozone concentrations are plotted on Figure 47 for the August 24 candidate day. This Figure can be used to detect instances of 25 and 50 percent disparity between the predicted and measured concentrations.

Figure 47a shows the frequency of occurrence of various values of a statistical "comparison factor". As the SMOG model's predictions approach agreement with the measured ozone concentrations, the comparison factor approaches zero. This graph also reveals the tendency for the model to under-predict or over-predict the measured concentrations. The negative comparison factors indicate under-prediction while the positive indicate over-prediction.

Figures 48 through 56 are reproductions of the actual computer output from the SMOG model. The grid squares are designated by the "I" and "J" values, and the grid cell concentrations are averaged over the indicated hour. Figures 57 through 69 are wind speed and direction plots, computer generated for August 24, and are reproduced output from the windflow field analysis program (14).

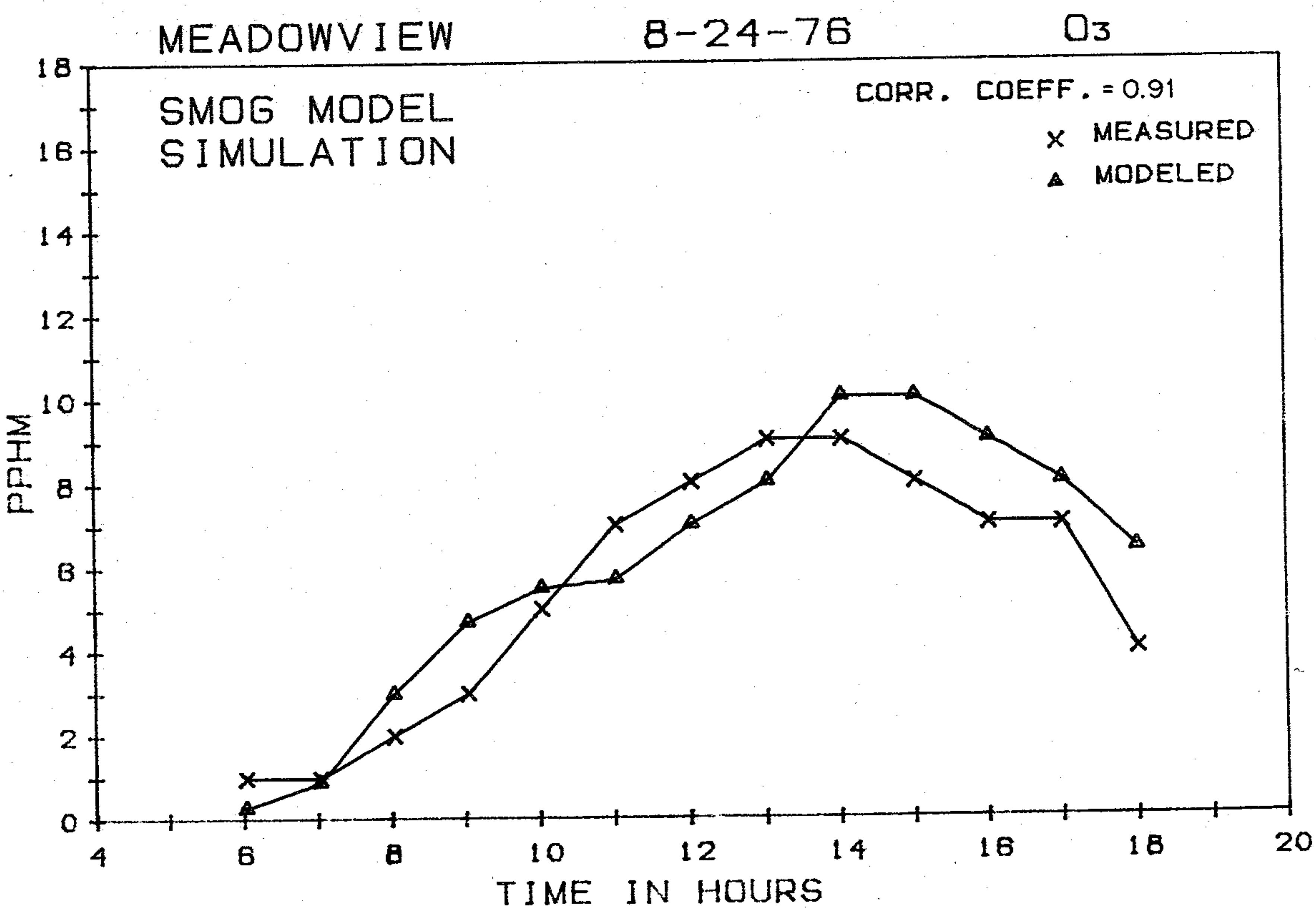

MEADOWVIEW
8-24-76
O3
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.91
X MEASURED
Δ MODELED
PPHM
TIME IN HOURS
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20

FIGURE 31

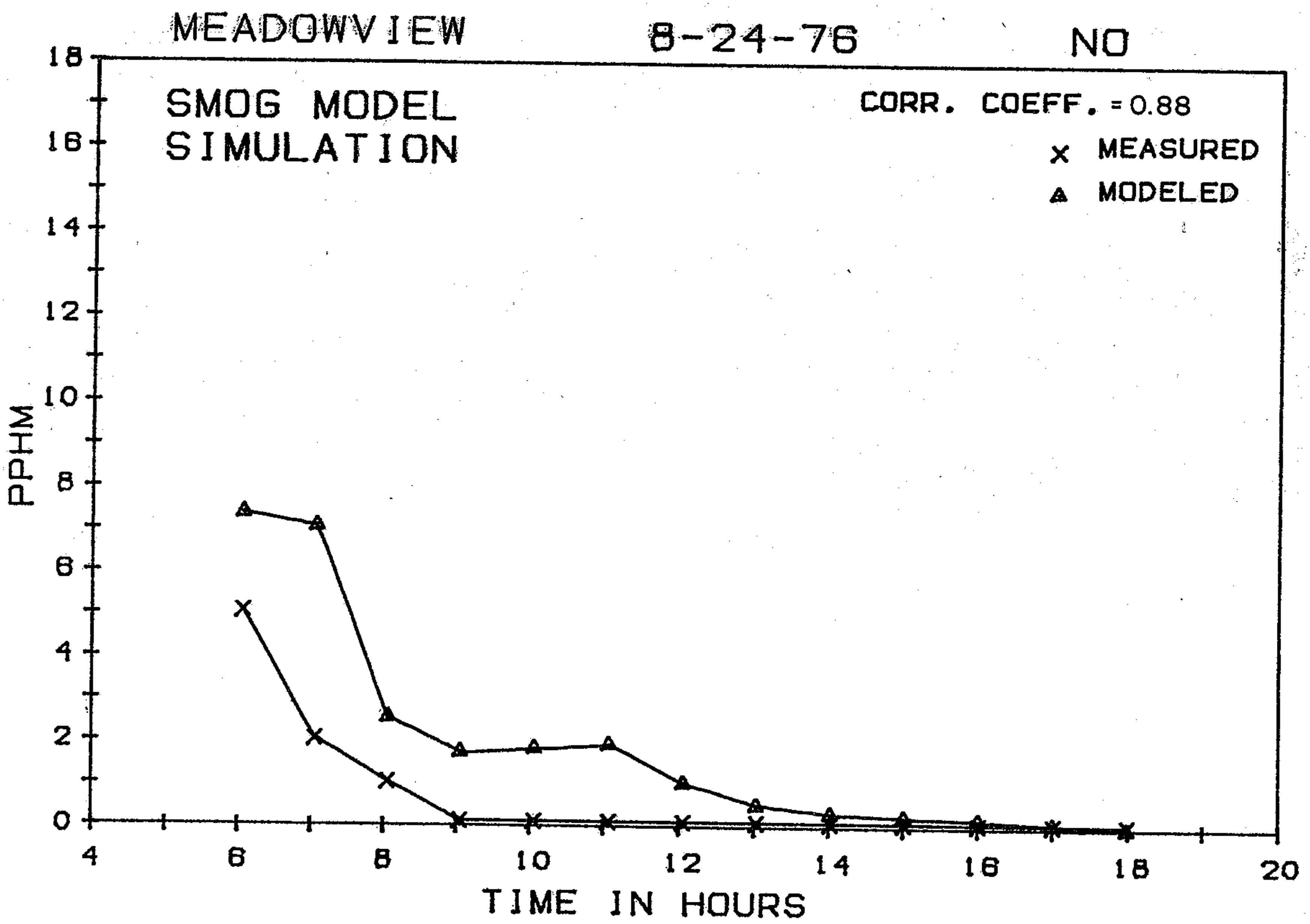

MEADOWVIEW
8-24-76
NO
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.88
× MEASURED
Δ MODELED
PPHM
18
16
14
12
10
8
6
4
2
0
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 32

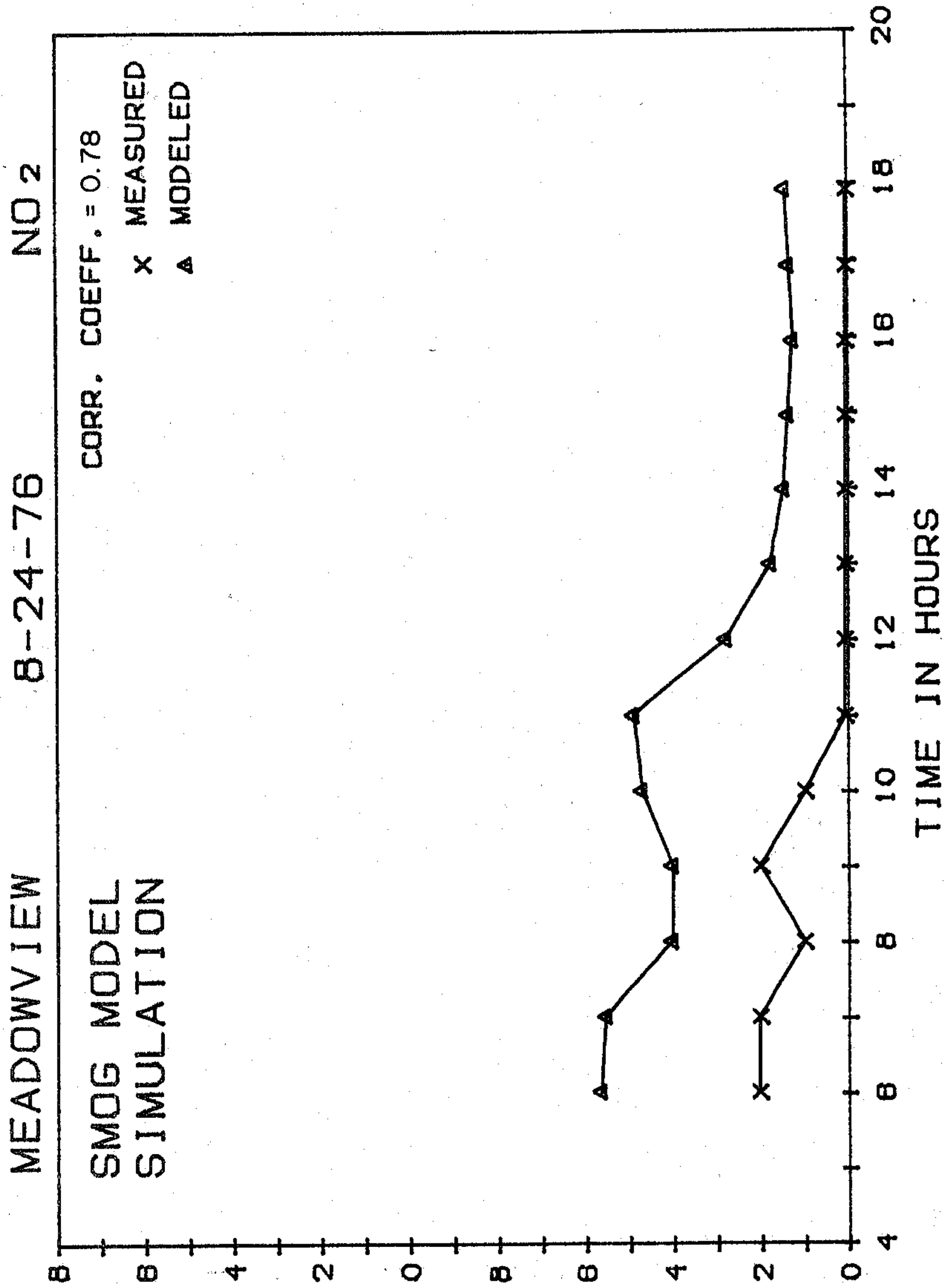

MEADOWVIEW
SMOG MODEL
SIMULATION
8-24-76
NO_2
CORR. COEFF. = 0.78
X MEASURED
Δ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
TIME IN HOURS
4
6
8
10
12
14
16
18
20

FIGURE 33

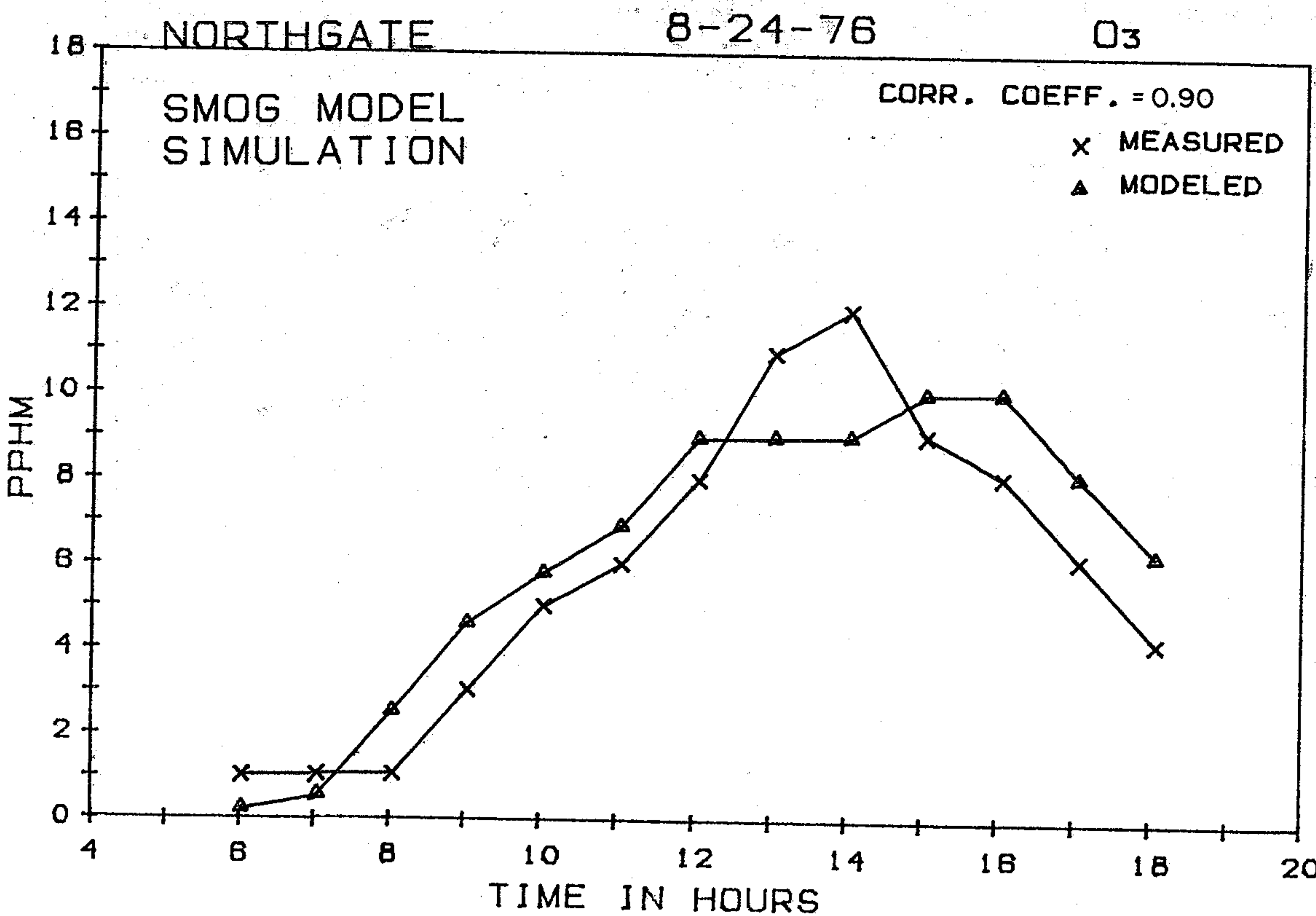

NORTHGATE
8-24-76
O3
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.90
MEASURED
MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 34

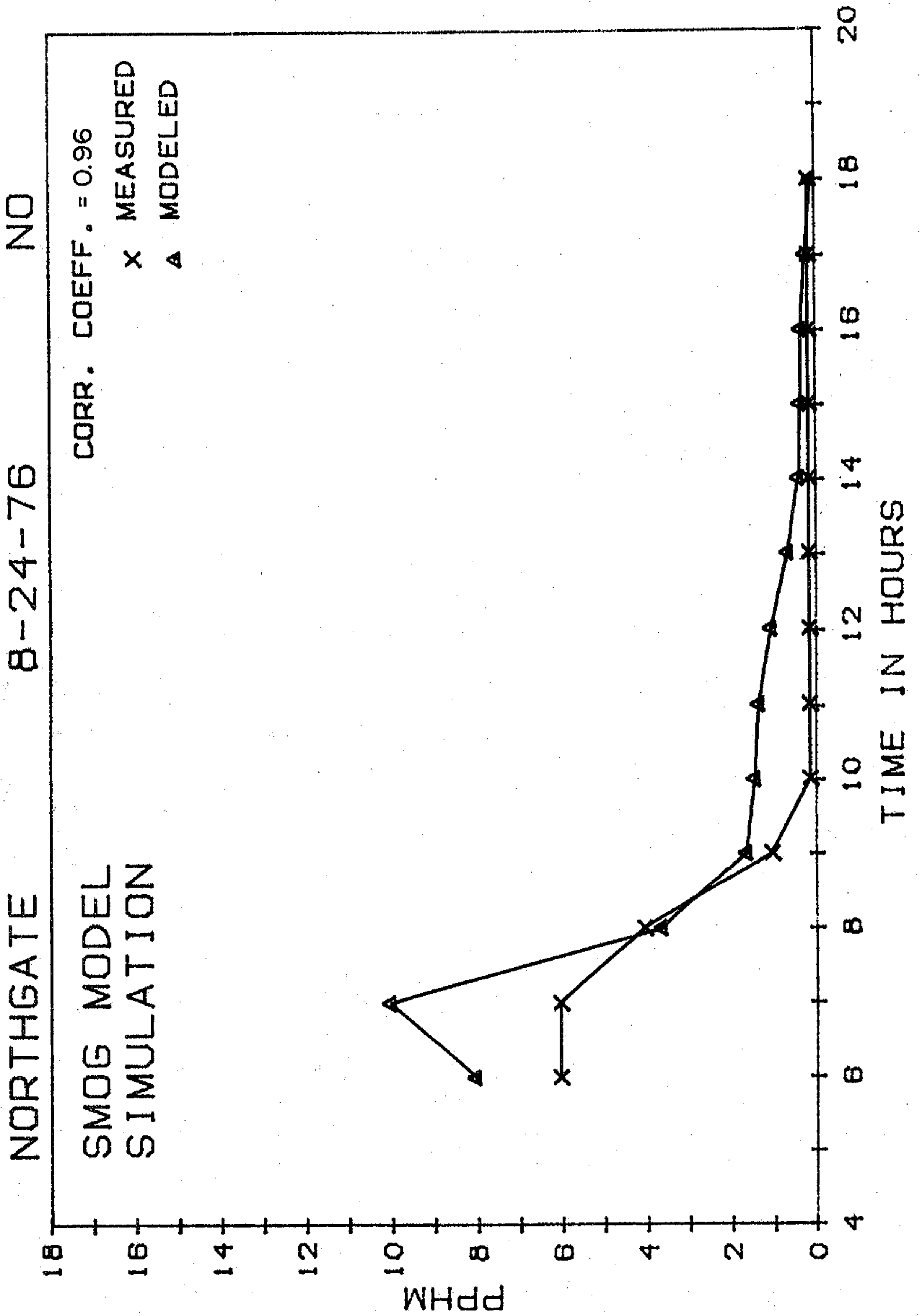

NORTHGATE
8-24-76
NO
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.96
X MEASURED
Δ MODELED
PPHM
TIME IN HOURS
0
2
4
6
8
10
12
14
16
18
20

FIGURE 35

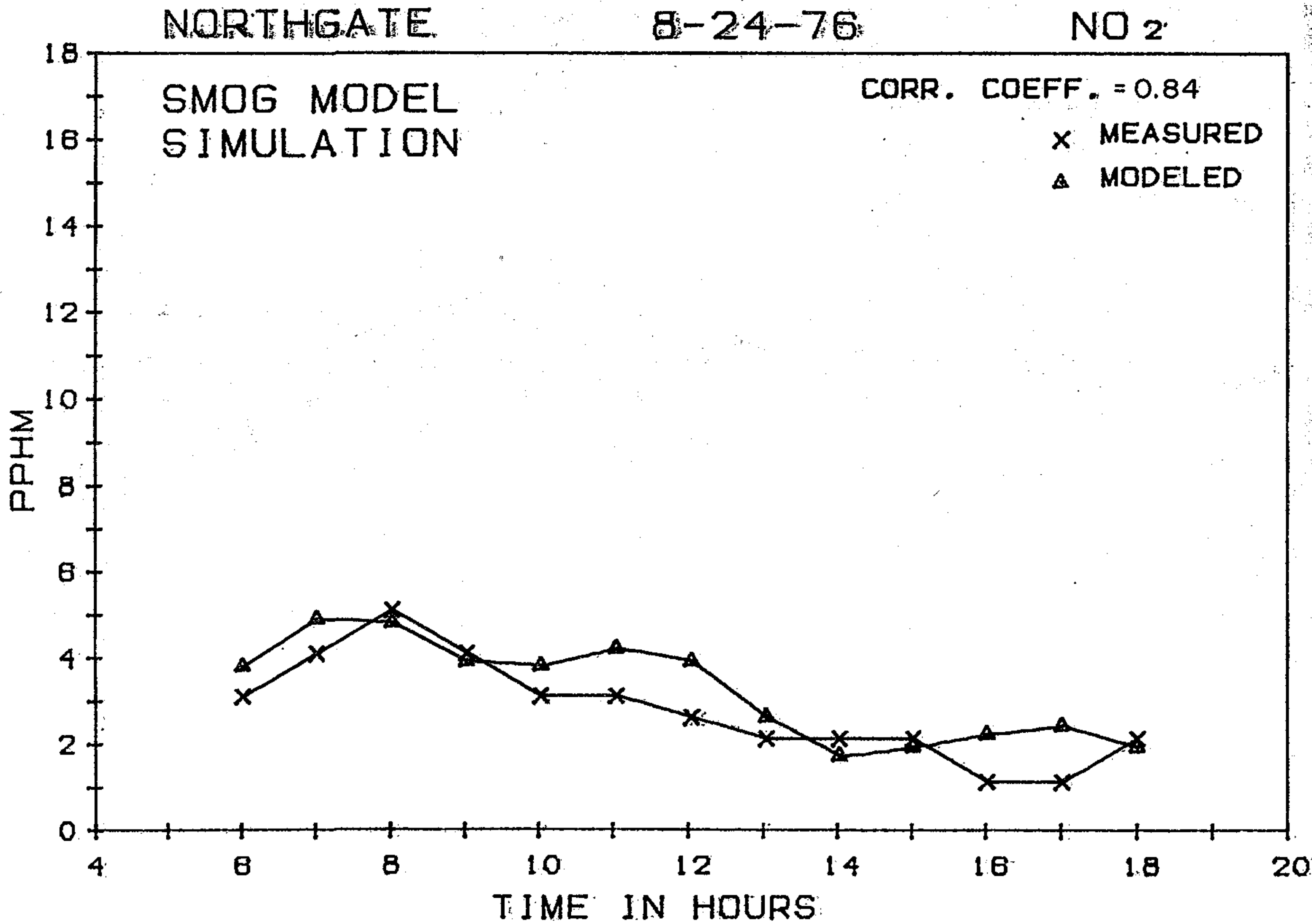

NORTHGATE
8-24-76
NO 2
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.84
× MEASURED
△ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 36

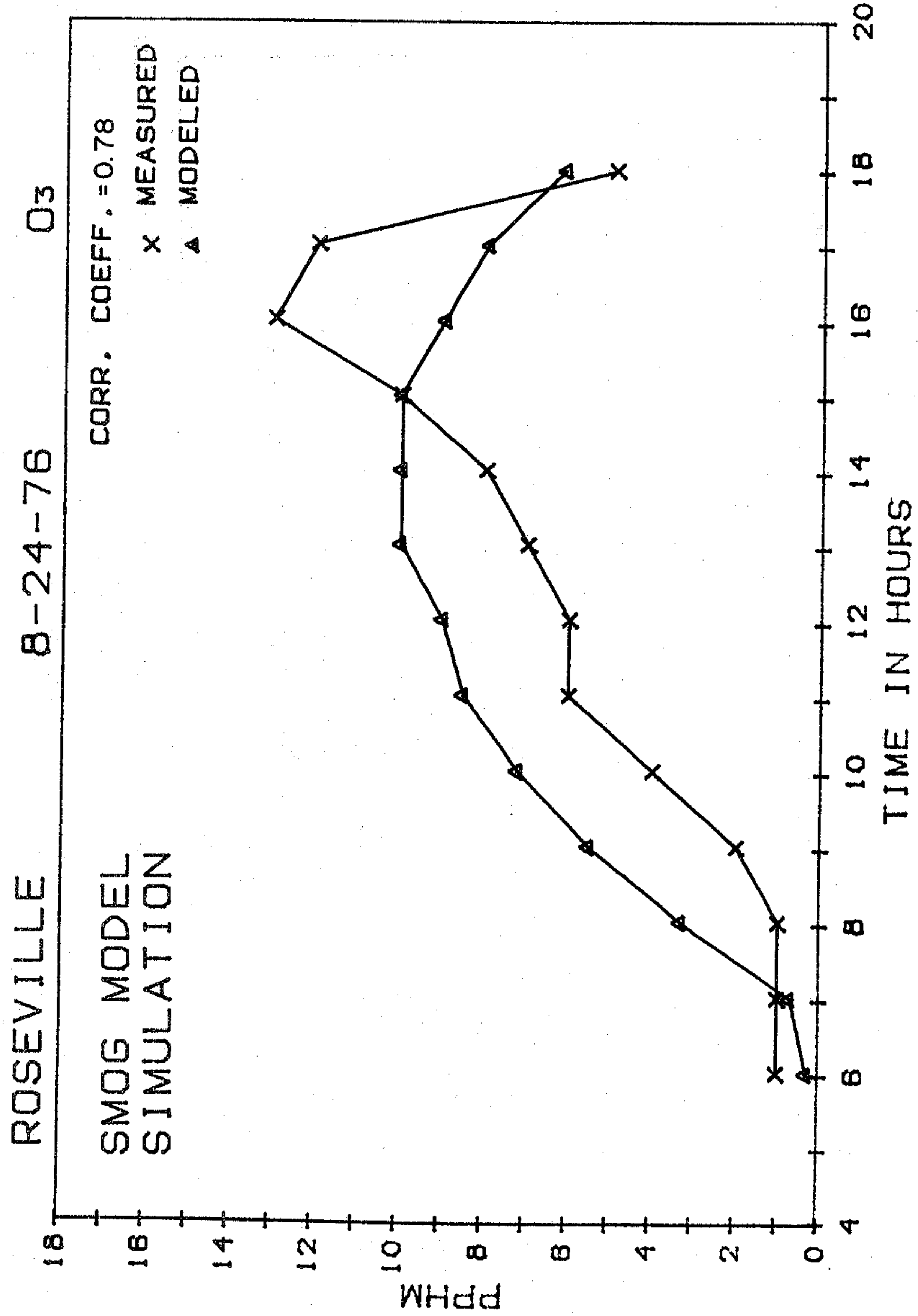

ROSEVILLE
8-24-76
O3
SMOG MODEL
SIMULATION
CORR. COEFF. =0.78
× MEASURED
▲ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
TIME IN HOURS
4
6
8
10
12
14
16
18
20

FIGURE 37

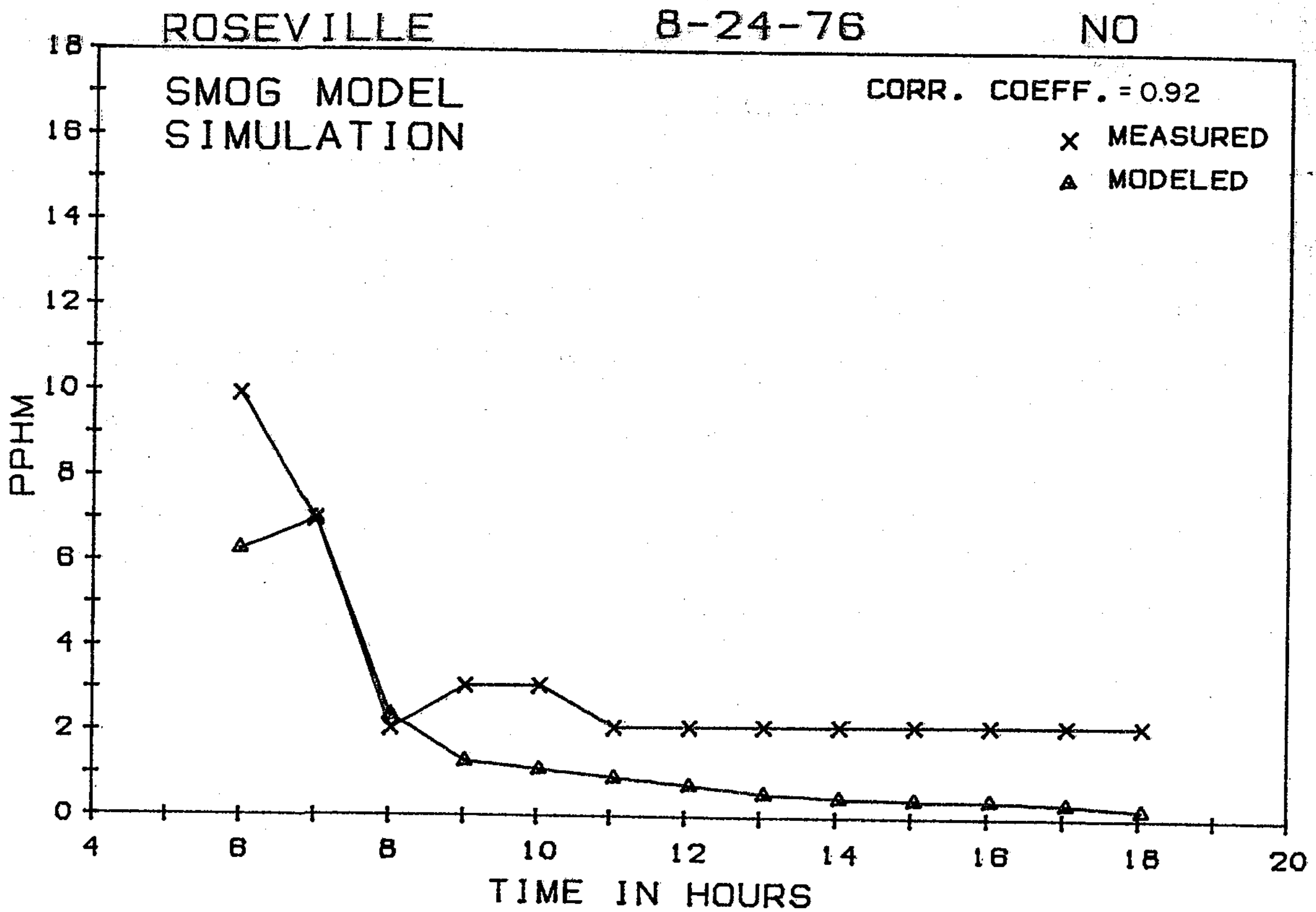

ROSEVILLE
8-24-76
NO
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.92
X MEASURED
Δ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 38

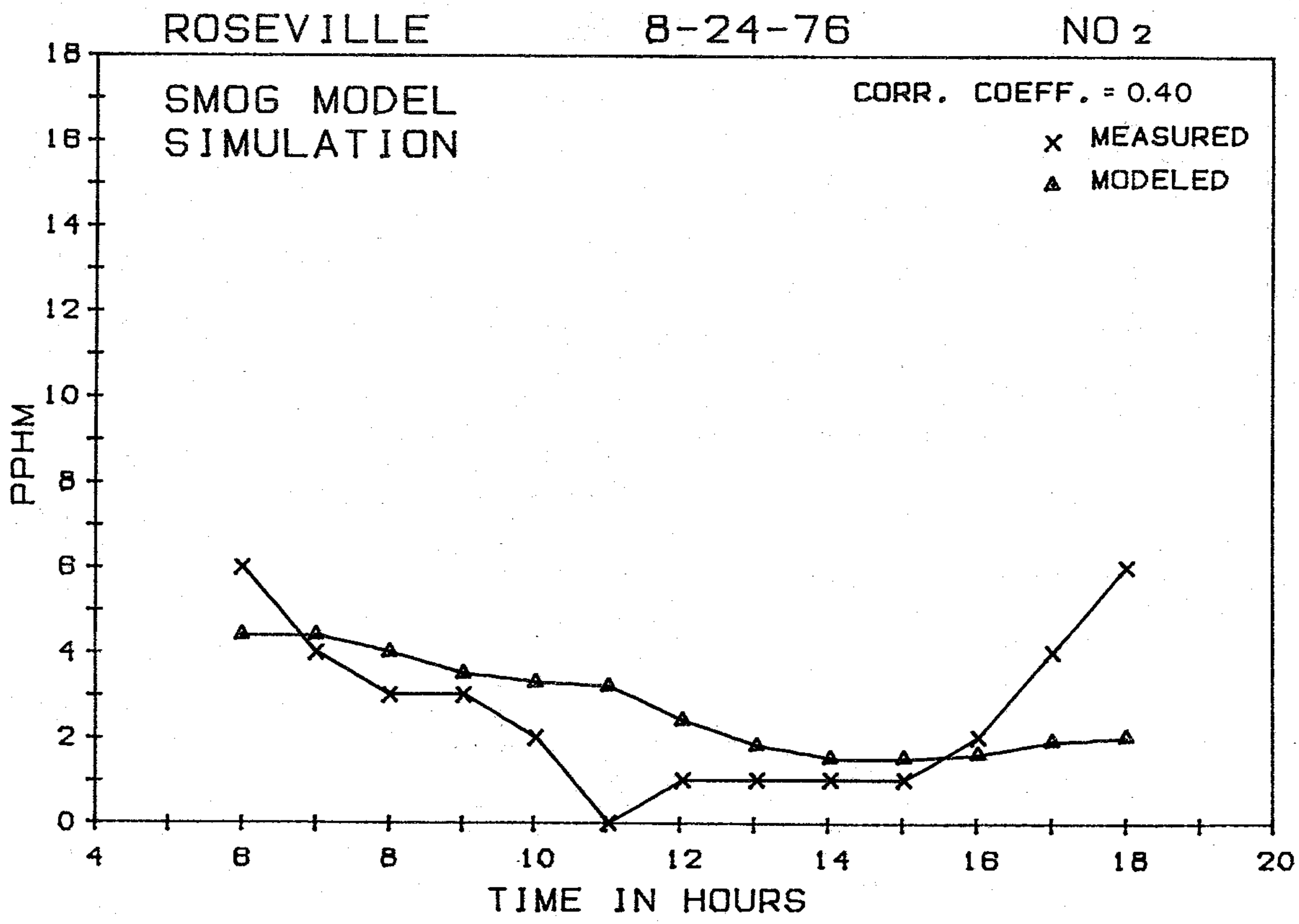

ROSEVILLE
8-24-76
NO 2
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.40
X MEASURED
Δ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 39

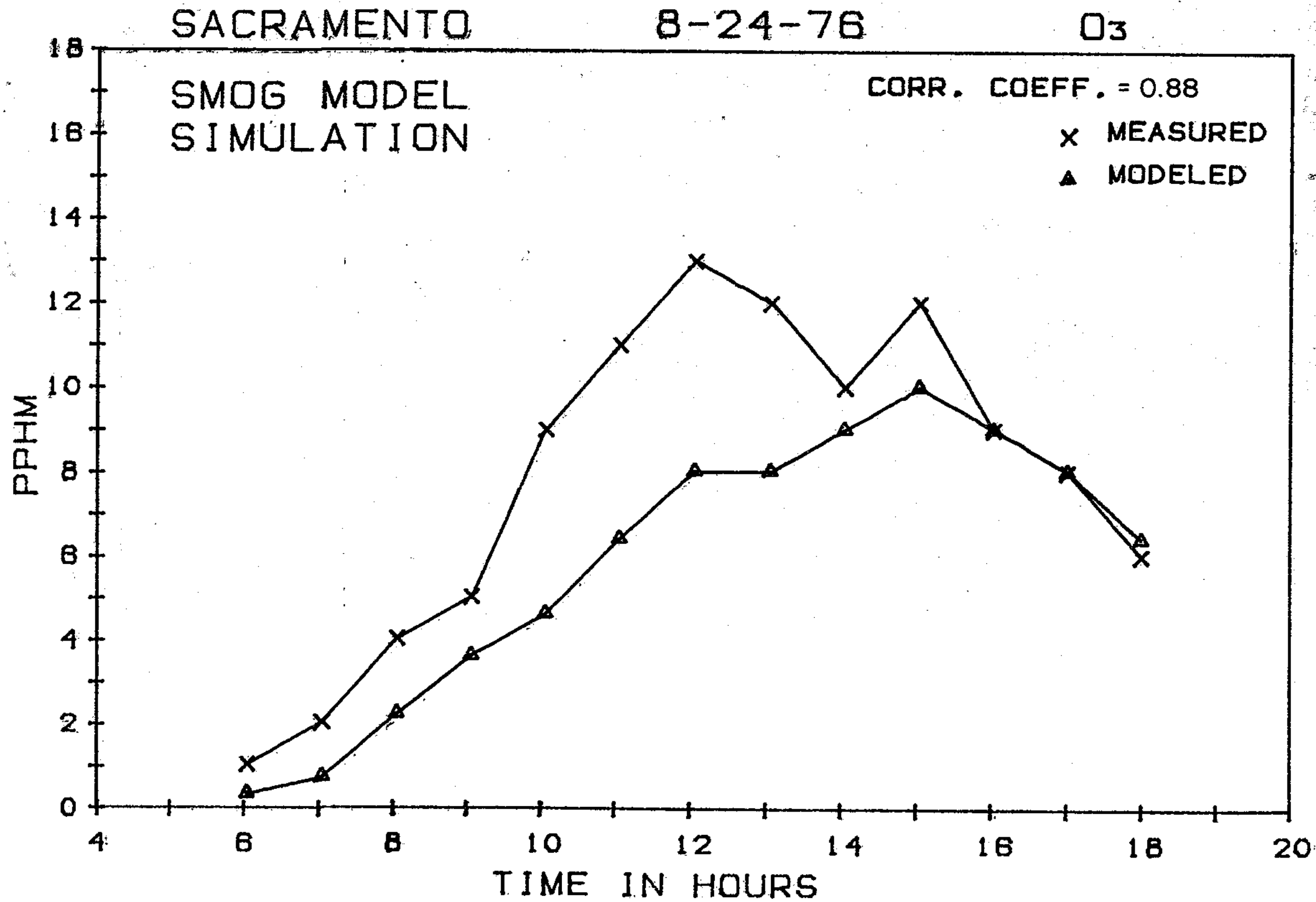

SACRAMENTO
8-24-76
O3
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.88
× MEASURED
▲ MODELED
PPHM
TIME IN HOURS
0
2
4
6
8
10
12
14
16
18
20

FIGURE 40

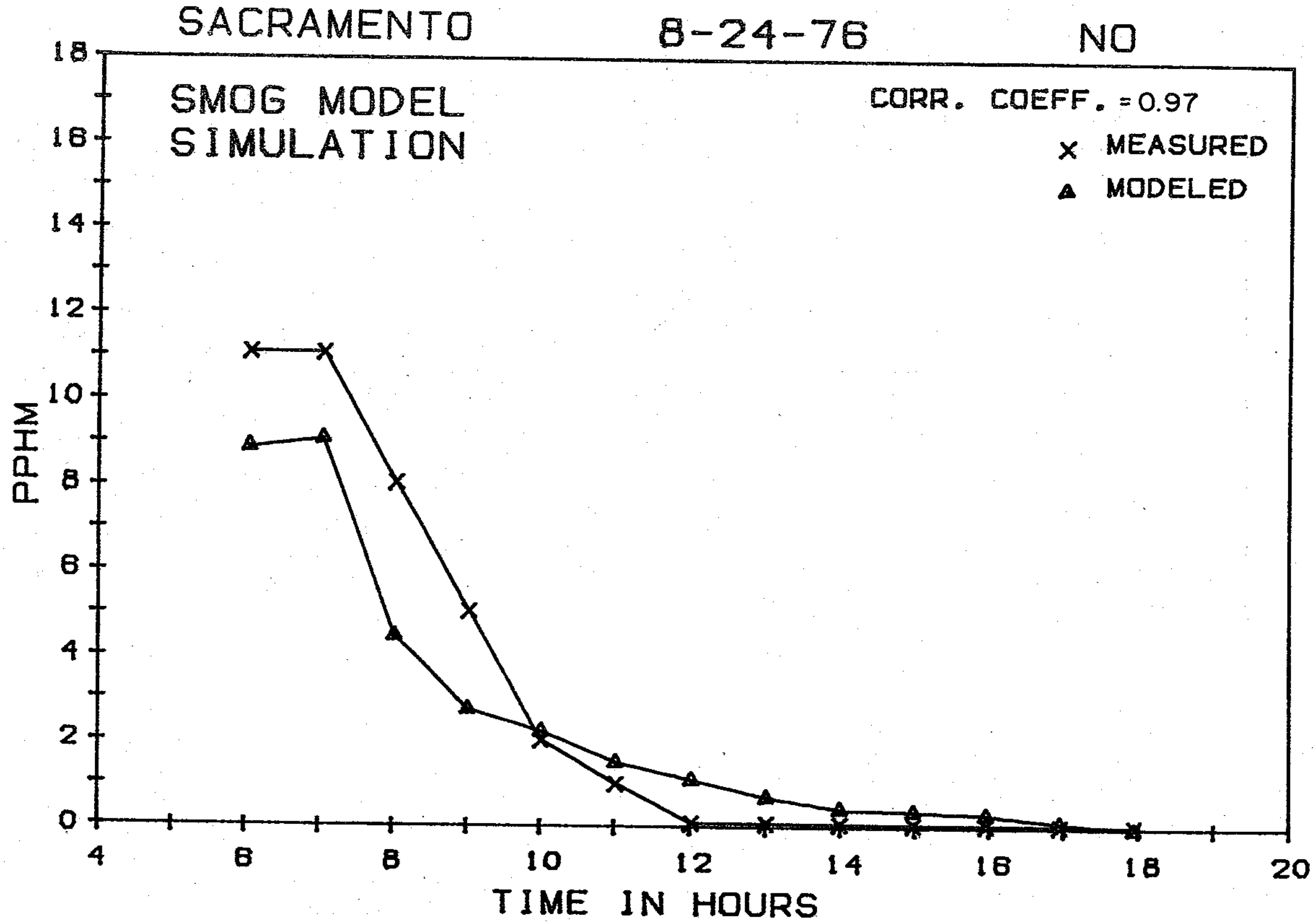

SACRAMENTO
8-24-76
NO
SMOG MODEL
SIMULATION
CORR. COEFF. =0.97
× MEASURED
▲ MODELED
PPHM
TIME IN HOURS
0
2
4
6
8
10
12
14
16
18
20

FIGURE 41

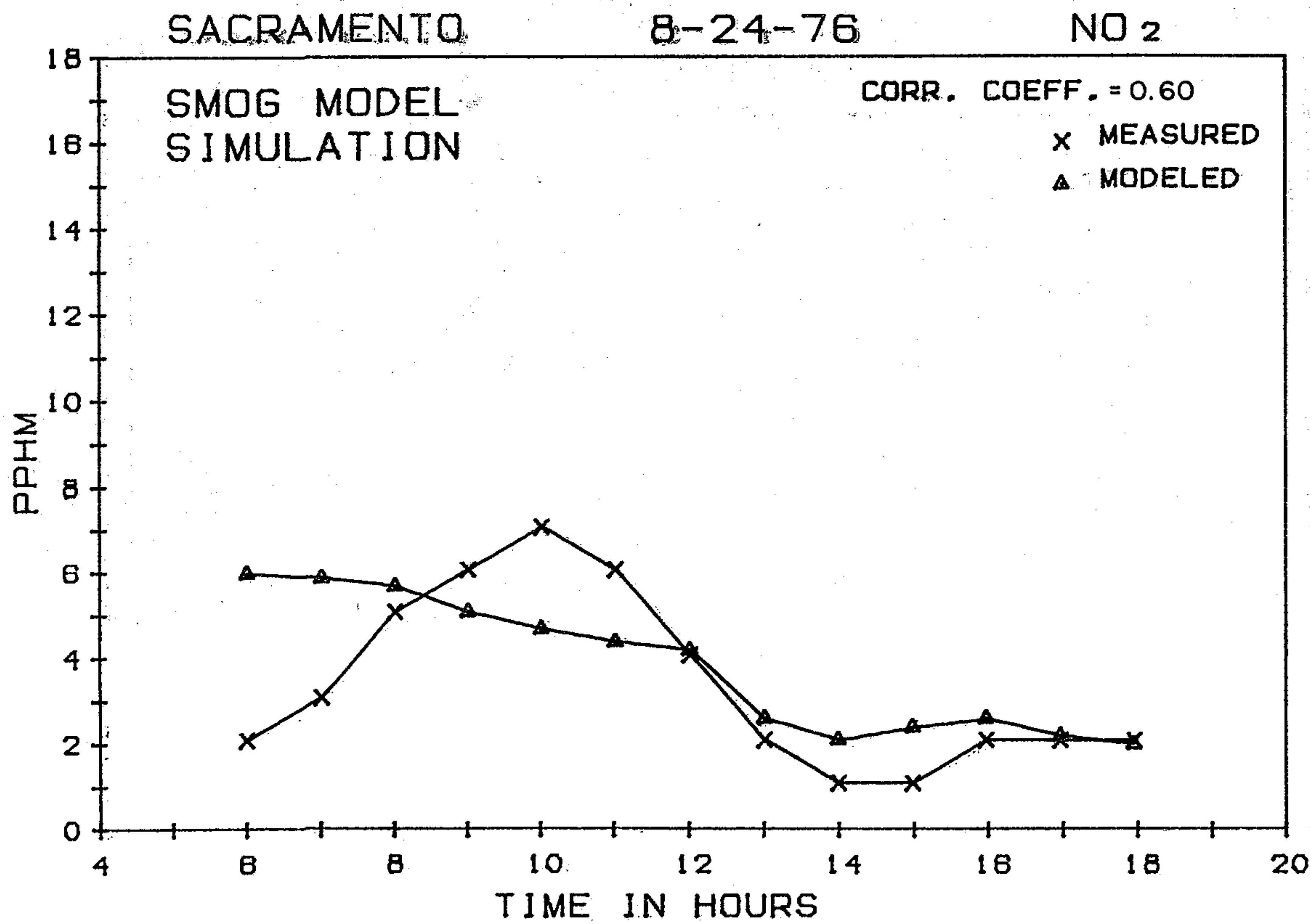

SACRAMENTO
8-24-76
NO 2
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.60
X MEASURED
Δ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 42

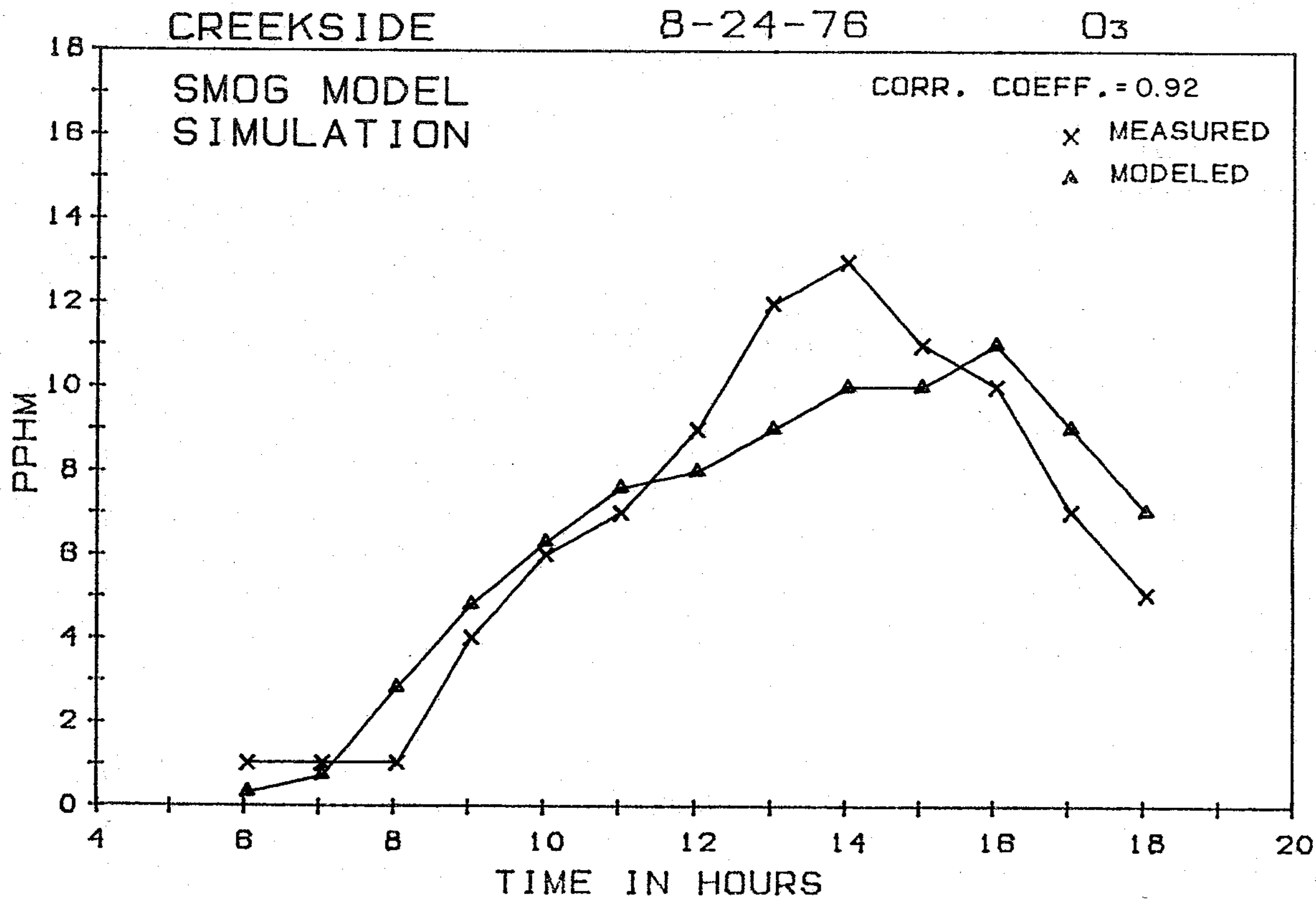

CREEKSIDE
8-24-76
O_3
SMOG MODEL
SIMULATION
CORR. COEFF.=0.92
× MEASURED
△ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 43

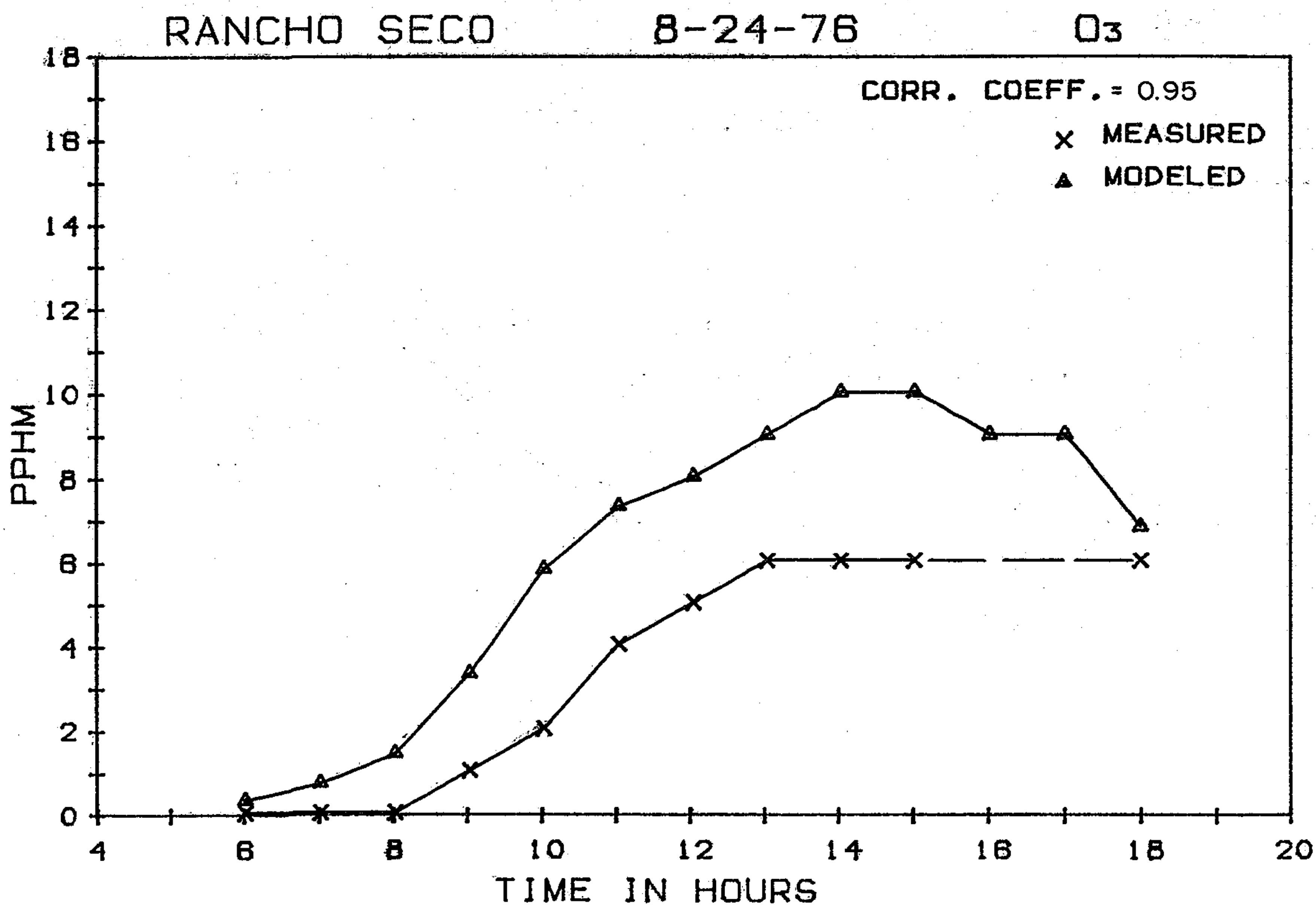

RANCHO SECO 8-24-76 O3
CORR. COEFF. = 0.95
MEASURED
MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 44

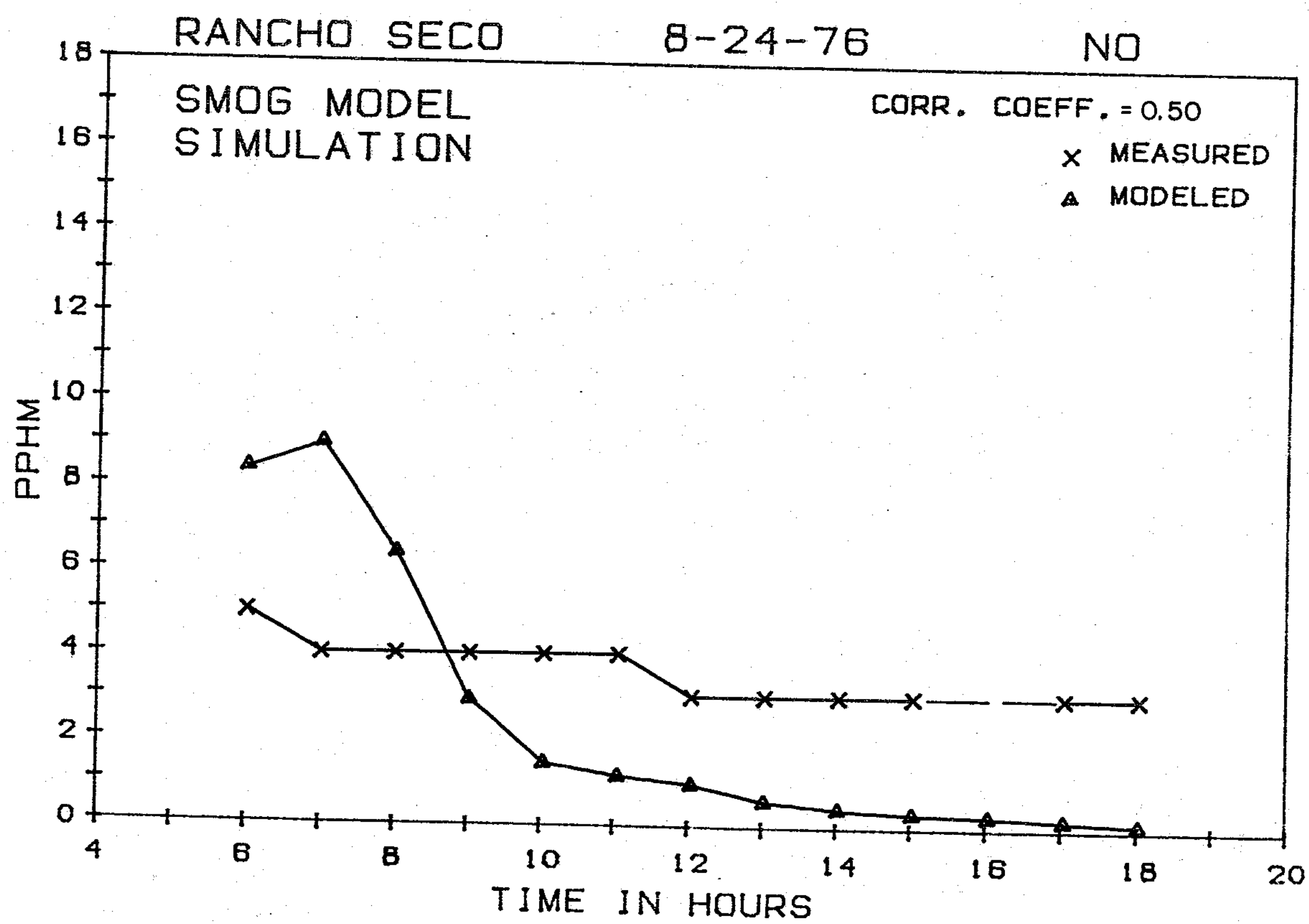

RANCHO SECO
8-24-76
NO
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.50
× MEASURED
△ MODELED
PPHM
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 45

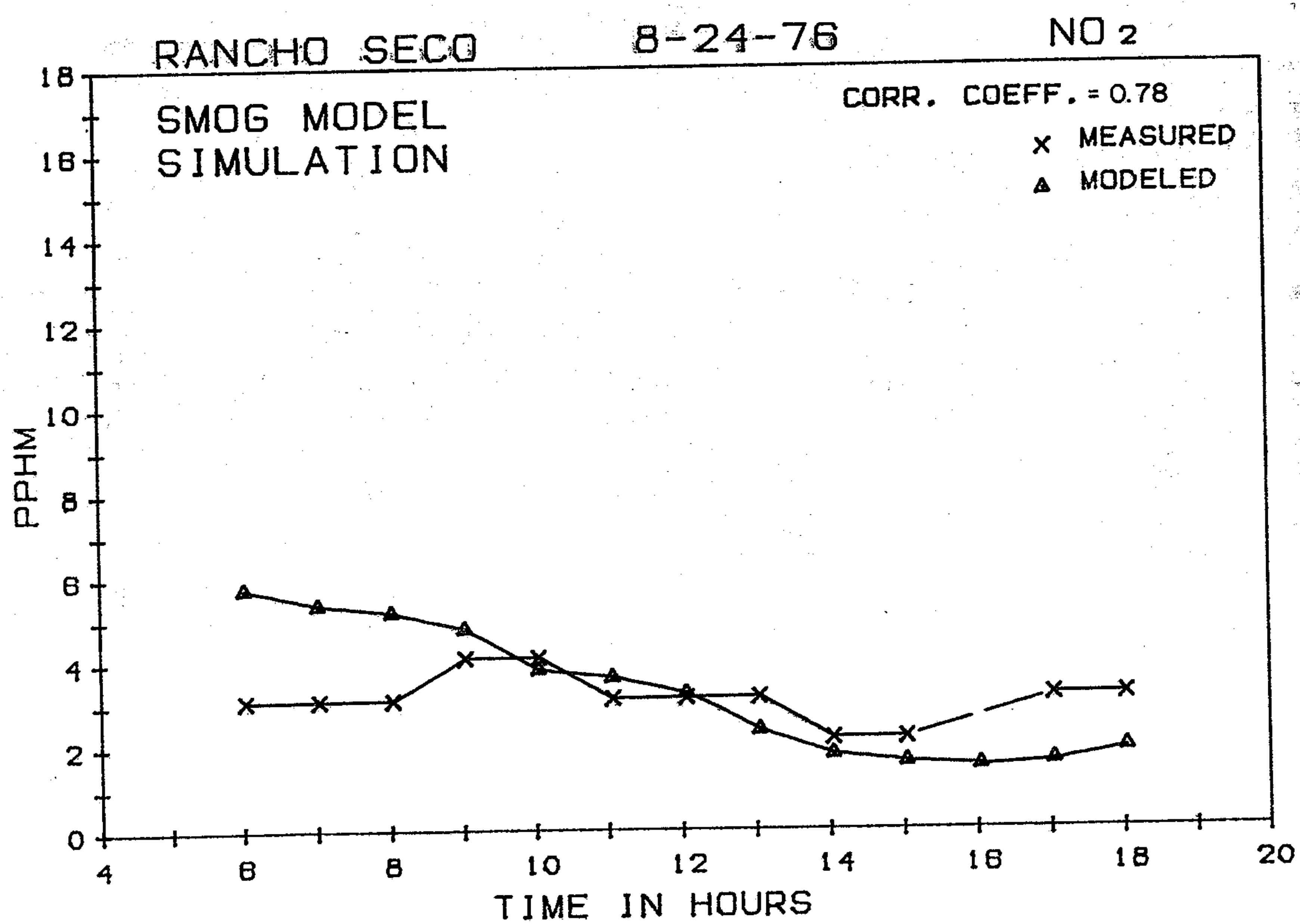
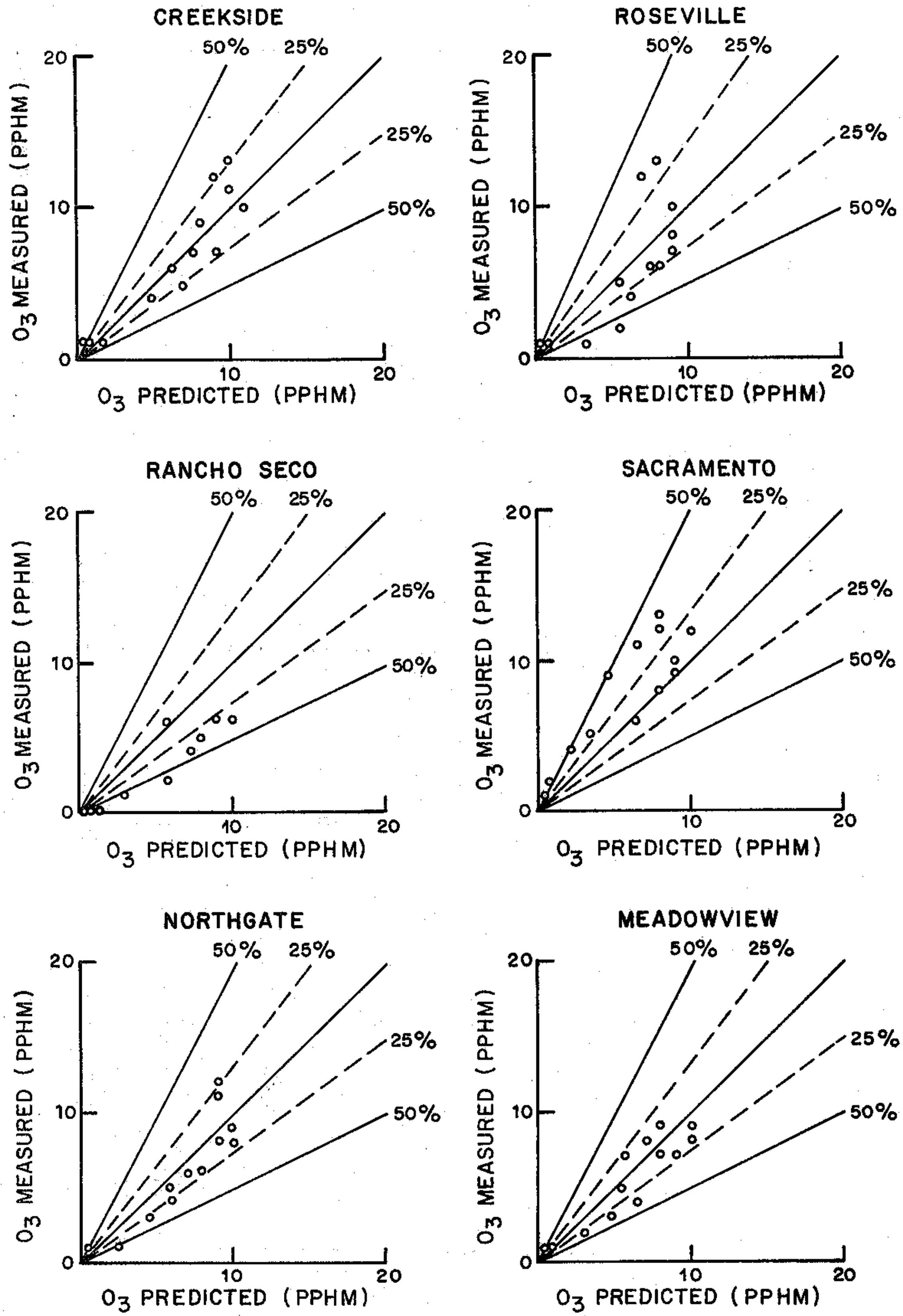
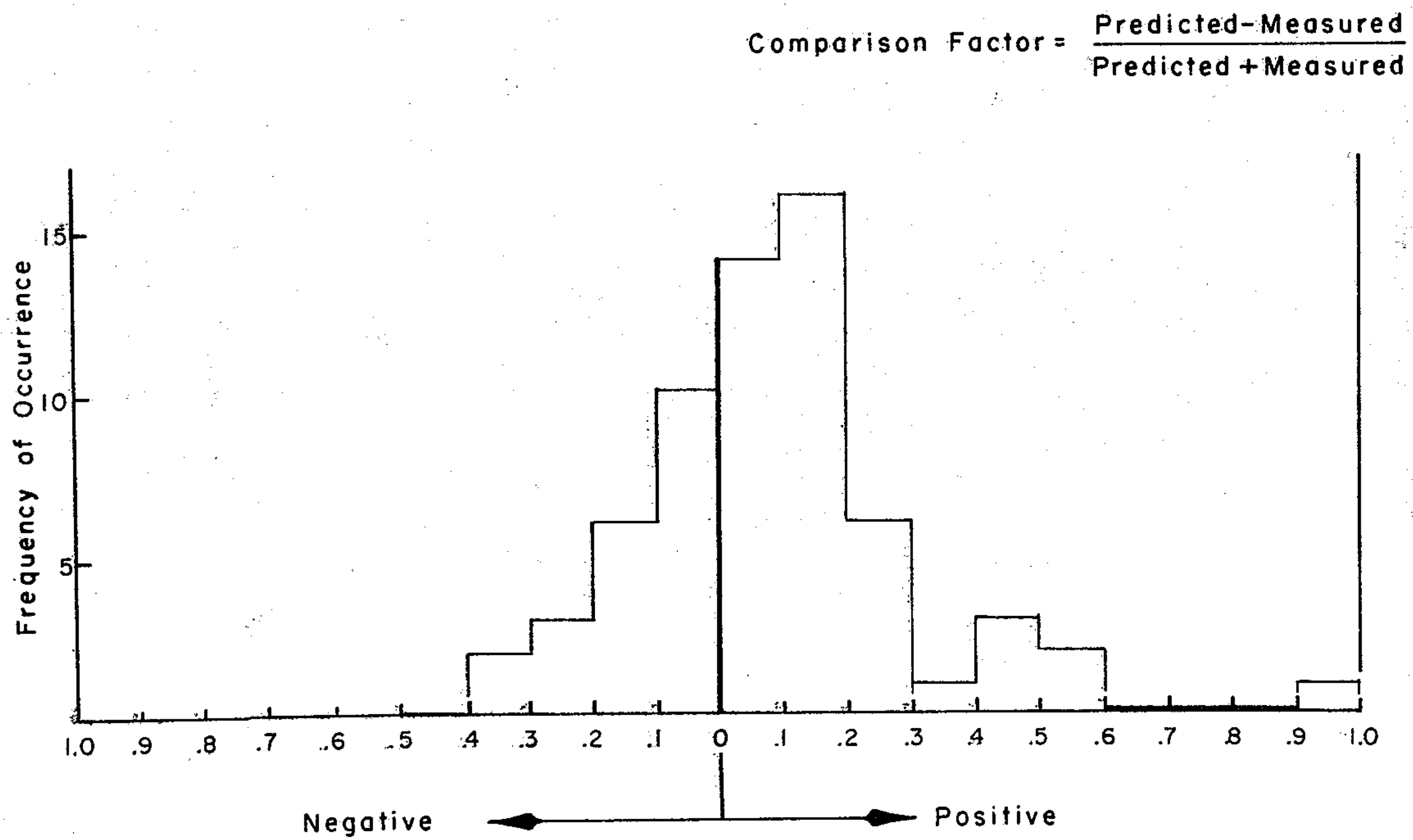

RANCHO SECO
8-24-76
NO 2
SMOG MODEL
SIMULATION
CORR. COEFF. = 0.78
MEASURED
MODELED
PPHM
18
16
14
12
10
8
6
4
2
0
4
6
8
10
12
14
16
18
20
TIME IN HOURS

FIGURE 46



SCATTER PLOTS MEASURED VS PREDICTED OZONE, SMOG MODEL
Sacramento Area, August 24, 1976
FIGURE 47



COMPARISON FACTOR – MEASURED AND MODELED OZONE CONCENTRATIONS

Sacramento Area, August 24, 1976

Figure 47a

SMOG MODEL O_3 RESULTS, "TWO-THIRDS HC" RUN
1000-1100 HOURS
8-24-76

SURFACE PRINT OF O3 PPM

MULTIPLIER= 1.00000E-03

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	68	60	55	55	58	59	59	62	66	68	72	74	77	77	79	76	78	79	78	78	67	77	72	64	61
J= 24	53	52	50	49	55	62	62	63	66	68	69	70	72	73	73	70	72	71	70	54	71	76	71	65	61
J= 23	46	45	49	50	56	64	67	66	66	67	68	66	67	66	64	62	65	65	65	70	54	75	70	65	61
J= 22	42	38	44	49	54	61	64	64	65	65	65	60	61	61	59	59	56	59	62	65	62	74	66	63	60
J= 21	45	38	39	46	52	57	60	62	64	64	63	57	58	60	58	54	54	58	61	66	59	70	65	62	60
J= 20	48	44	40	42	49	53	55	59	65	67	64	58	59	62	59	57	53	56	60	64	63	67	63	60	58
J= 19	48	49	49	48	50	53	55	56	61	69	68	64	63	64	63	60	54	52	56	57	50	53	53	53	53
J= 18	50	51	55	57	57	57	59	59	63	68	69	67	64	65	67	64	54	51	54	53	45	58	49	47	48
J= 17	53	56	60	65	64	61	58	57	58	61	61	65	61	66	65	60	56	54	54	55	46	45	43	42	42
J= 16	51	56	62	66	65	64	60	57	57	61	60	63	63	63	61	59	55	53	55	58	57	47	37	44	41
J= 15	49	50	56	63	62	61	60	55	54	57	56	63	61	62	59	56	52	52	55	57	56	55	54	37	44
J= 14	45	43	44	51	54	54	54	50	52	58	59	64	63	60	57	52	50	50	49	50	49	49	51	57	41
J= 13	44	41	38	39	43	49	49	46	46	57	60	65	64	62	58	53	50	49	49	51	53	54	53	51	54
J= 12	47	52	51	45	47	55	57	54	44	52	62	63	65	64	62	55	50	48	47	48	51	53	55	58	52
J= 11	52	52	50	47	48	57	62	63	53	54	57	60	63	61	60	55	49	46	48	49	52	56	58	58	56
J= 10	55	53	50	54	55	57	64	66	60	51	55	58	57	55	54	53	50	47	46	47	51	55	57	58	52
J= 9	53	51	52	54	58	59	61	63	66	56	47	51	52	50	51	52	49	50	48	47	51	55	56	57	52
J= 8	51	51	51	50	50	53	52	52	55	56	45	44	44	43	46	48	49	50	49	51	53	56	56	56	53
J= 7	44	42	42	43	44	44	45	45	44	46	42	36	35	33	37	43	48	52	51	53	54	55	55	56	52
J= 6	38	37	38	37	38	39	39	39	40	39	37	33	32	33	35	42	48	53	56	57	58	55	54	55	53
J= 5	36	36	37	37	38	39	39	38	37	36	36	34	33	34	39	45	51	55	59	61	59	55	53	54	52
J= 4	40	41	42	42	43	43	43	41	40	38	37	35	33	37	42	50	54	56	59	58	58	57	53	53	51
J= 3	46	47	47	47	48	48	48	46	44	41	40	38	36	38	46	55	60	61	59	56	55	54	55	55	51
J= 2	48	49	49	49	49	49	48	47	46	44	43	41	41	41	47	56	60	63	62	60	57	53	57	56	50
J= 1	45	45	45	45	45	45	45	44	44	43	41	40	40	42	45	53	57	58	58	59	57	54	56	58	52

FIGURE 48

SMOG MODEL O_3 RESULTS, "TWO-THIRDS HC" RUN
1300-1400 HOURS
8-24-76

SURFACE PRINT OF O3 PPM

MULTIPLIER= 1.00000E-02

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	9	9	9	9	9	9	10	10	10	11	11	11	11	11	11	10	10	9	9	9	8	9	9	10	10
J= 24	9	9	9	9	9	9	9	10	10	10	11	11	11	10	11	10	10	10	10	9	9	10	10	10	10
J= 23	8	9	9	9	9	9	10	10	10	10	11	11	11	10	10	10	10	10	10	10	9	11	10	11	11
J= 22	8	9	9	9	9	9	10	10	10	10	11	11	10	10	10	10	9	10	10	10	10	11	11	11	11
J= 21	8	9	9	8	9	9	10	11	11	10	10	10	10	9	9	9	9	10	10	10	9	11	10	10	10
J= 20	9	9	9	8	9	9	10	11	11	10	9	9	9	9	9	9	9	10	10	10	10	9	10	9	10
J= 19	8	9	9	9	9	9	9	10	10	10	9	9	9	9	9	8	9	9	10	10	9	10	10	10	9
J= 18	8	9	9	9	9	8	9	10	9	9	9	9	9	9	9	9	9	9	10	10	11	9	10	10	9
J= 17	8	9	9	9	9	9	9	9	9	9	9	9	8	9	9	10	10	11	11	12	10	10	10	10	9
J= 16	9	9	9	9	9	9	9	8	9	9	9	9	9	10	10	11	11	11	11	10	10	10	8	9	9
J= 15	9	9	9	9	9	8	9	9	8	8	8	9	9	10	10	10	10	10	10	10	10	9	10	8	9
J= 14	9	10	9	9	9	8	9	8	8	9	9	10	10	10	10	9	9	10	10	10	9	9	9	9	9
J= 13	9	9	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
J= 12	9	9	8	8	8	9	9	9	8	9	8	8	8	9	9	9	8	8	9	9	9	9	9	9	9
J= 11	9	9	9	9	9	9	8	8	8	8	8	8	8	9	9	9	8	8	8	8	9	9	9	9	9
J= 10	9	9	9	9	9	9	9	8	8	8	8	8	8	8	8	8	7	8	8	8	9	9	9	9	9
J= 9	9	9	9	9	9	9	8	8	8	8	8	8	8	8	8	7	7	8	8	9	9	9	9	9	8
J= 8	9	9	9	9	9	8	8	8	8	8	8	8	8	9	8	7	8	9	9	9	9	9	9	8	8
J= 7	9	9	9	9	9	8	8	8	8	8	9	8	9	9	8	8	8	9	10	9	9	9	8	8	8
J= 6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	8	9	10	9	9	9	8	8	8	8
J= 5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	9	9	8	8	8	8	8
J= 4	8	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	9	9	9	9	9	8	8
J= 3	8	9	9	9	9	9	9	9	9	9	9	9	9	9	8	8	9	9	9	9	9	9	9	9	9
J= 2	8	9	9	9	9	8	8	8	8	9	9	9	9	9	8	8	8	8	8	9	9	9	9	9	9
J= 1	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9

FIGURE 49

SMOG MODEL O_3 RESULTS, "TWO-THIRDS HC" RUN
1600-1700 HOURS
8-24-76

SURFACE PRINT OF 03 PPM

MULTIPLIER= 1.00000E-02

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	8	9	10	11	11	11	11	11	10	10	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
J= 24	8	9	10	10	11	11	11	11	11	10	9	9	9	9	9	9	9	8	9	9	9	9	10	10	10
J= 23	8	9	9	10	10	11	11	11	11	10	9	9	9	9	9	9	8	8	9	9	8	10	10	10	10
J= 22	8	9	9	9	10	10	11	11	11	9	9	9	9	9	9	9	8	9	9	9	10	10	10	10	10
J= 21	8	9	8	9	10	10	11	11	10	9	9	9	9	9	9	8	8	8	9	9	9	10	10	10	10
J= 20	8	8	9	9	9	10	11	11	10	9	9	9	8	8	8	8	8	8	9	9	10	10	11	10	10
J= 19	8	9	9	9	9	9	10	11	10	10	9	9	9	8	8	8	8	8	9	10	11	11	11	10	10
J= 18	8	9	9	9	9	9	9	10	11	11	10	9	9	8	8	9	9	9	10	11	11	10	10	10	10
J= 17	8	9	9	9	9	9	9	10	10	10	10	10	9	9	9	9	9	10	10	11	9	9	9	9	9
J= 16	8	9	9	9	9	9	9	9	10	10	10	10	10	10	9	9	10	10	10	10	10	10	8	9	9
J= 15	8	9	9	8	9	9	9	9	9	9	9	11	10	10	10	9	9	9	10	10	10	9	10	8	9
J= 14	8	8	8	8	9	9	9	9	9	9	10	10	10	9	10	9	9	9	10	9	9	9	9	9	9
J= 13	8	8	8	8	9	9	9	9	9	9	10	9	9	10	9	10	10	9	9	9	9	9	9	9	9
J= 12	8	8	9	9	9	9	10	11	9	9	9	9	10	10	10	10	10	9	10	10	9	9	9	9	9
J= 11	8	8	8	8	9	9	10	10	9	9	9	9	10	10	10	10	10	10	10	10	9	9	9	9	9
J= 10	8	8	9	9	9	10	10	10	9	9	9	9	9	10	10	10	10	10	10	9	9	9	9	9	9
J= 9	8	8	9	9	9	10	10	9	9	9	8	9	9	9	10	10	10	10	10	9	9	9	9	9	9
J= 8	8	8	9	9	9	10	9	9	9	9	9	9	9	10	10	10	10	10	10	10	9	9	9	9	9
J= 7	8	8	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	9	9	9	9	9
J= 6	8	8	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	9	9	9	9	9
J= 5	8	8	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	9	9	9	9	9
J= 4	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	9	9	9	9	9	9	9
J= 3	8	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
J= 2	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
J= 1	9	9	10	10	10	10	10	10	10	9	9	10	9	10	9	9	9	9	9	9	9	9	9	9	9

FIGURE 50

SMOG MODEL O_3 RESULTS, ZERO EMISSIONS RUN
1000–1100 HOURS
8-24-76

SURFACE PRINT OF O3 PPM

MULTIPLIER= 1.00000E-02

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	10	10	9	9	9	9	9	10	10	11	11	11	11	10	10	10	10	11	11	11	9	9	8	7	6
J= 24	9	8	8	8	8	9	9	9	10	10	10	10	10	10	10	10	10	10	10	7	9	9	8	7	6
J= 23	8	7	7	7	8	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	7	9	8	7	6
J= 22	7	6	6	6	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	9	8	9	7	6	6
J= 21	7	6	5	6	7	7	8	8	8	8	8	7	8	8	8	8	7	8	8	9	7	8	7	6	6
J= 20	7	6	6	6	6	7	7	8	8	9	8	8	8	8	8	8	7	8	8	8	8	8	7	6	6
J= 19	7	6	6	6	7	7	7	7	8	9	9	8	8	8	9	8	7	7	7	7	6	6	6	6	5
J= 18	7	7	7	7	7	8	8	8	9	9	9	9	9	9	9	8	7	7	7	7	6	7	6	5	5
J= 17	7	7	8	8	8	8	8	8	8	8	9	9	8	8	8	8	8	7	7	7	6	5	5	5	4
J= 16	7	7	8	8	8	8	8	8	8	9	8	8	8	8	8	8	8	7	7	7	7	6	4	5	4
J= 15	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	7	6	4	4
J= 14	6	6	6	7	7	7	7	7	8	8	8	9	8	8	8	7	7	7	7	7	6	6	6	6	4
J= 13	6	6	6	6	6	7	7	7	7	8	9	9	9	8	8	7	7	7	7	7	7	7	6	6	6
J= 12	7	7	7	6	6	7	7	7	7	7	9	8	9	8	8	7	7	7	6	7	7	6	6	6	5
J= 11	7	7	7	7	7	8	8	8	8	7	8	8	8	8	8	7	7	6	7	7	7	7	6	6	6
J= 10	7	7	7	7	7	8	9	9	8	8	7	8	7	7	7	7	7	6	6	6	6	6	6	6	5
J= 9	7	7	7	7	8	8	8	8	8	8	7	7	6	6	6	7	6	7	6	6	6	6	6	6	5
J= 8	6	6	6	6	6	7	6	7	7	7	6	6	5	5	6	6	6	7	6	7	6	6	6	6	5
J= 7	5	5	5	5	5	5	5	5	5	6	5	5	4	4	4	5	6	7	7	7	6	6	6	6	5
J= 6	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	7	7	7	7	6	6	6	5
J= 5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	5	7	7	7	6	6	6	5
J= 4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	6	6	6	6	6	6	6	5
J= 3	5	5	5	5	5	5	5	4	4	4	4	4	4	4	5	6	6	6	6	6	6	6	6	6	6
J= 2	5	5	5	5	5	5	5	5	5	4	4	4	4	4	5	6	6	6	6	6	6	5	6	6	5
J= 1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	6	6	6	6	6	5	6	6	5

FIGURE 51

SMOG MODEL O_3 RESULTS, ZERO EMISSIONS RUN
1300-1400 HOURS
8-24-76

SURFACE PRINT OF O3 PPM

MULTIPLIER= 1.00000E-02

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	8	9	10	11	11	11	12	12	12	13	13	13	12	12	12	11	10	10	9	9	8	9	9	10	10
J= 24	9	9	9	10	10	10	11	11	12	12	12	12	12	12	12	12	11	11	10	9	9	10	10	11	11
J= 23	8	9	9	10	10	10	11	12	12	11	13	13	12	12	12	12	11	11	10	10	9	11	11	12	12
J= 22	8	9	9	9	9	10	11	11	12	12	13	12	12	11	11	11	11	11	11	11	11	12	12	13	12
J= 21	8	9	9	9	9	10	11	12	12	12	12	11	11	11	10	10	11	11	11	11	11	13	12	12	12
J= 20	8	9	9	9	9	10	10	12	12	11	10	10	10	9	9	9	10	11	11	11	11	11	11	11	11
J= 19	8	9	9	9	9	10	10	11	11	10	9	9	9	10	9	9	10	11	11	11	11	11	11	11	11
J= 18	8	9	9	9	9	9	9	11	10	10	10	10	10	10	10	10	10	11	12	12	12	11	12	12	12
J= 17	9	9	9	9	9	9	9	10	10	11	10	10	10	10	10	11	11	12	13	14	12	13	12	12	12
J= 16	9	9	9	9	9	9	9	9	10	11	10	10	10	11	12	12	12	13	13	12	12	12	10	12	11
J= 15	9	10	10	10	9	9	9	10	10	10	11	11	11	11	12	12	12	12	12	12	12	11	12	10	11
J= 14	10	11	10	10	9	9	9	9	10	11	11	12	12	12	11	11	11	12	12	12	11	11	11	11	10
J= 13	9	10	9	9	9	9	9	9	10	11	11	11	11	11	11	10	10	10	11	11	11	10	10	10	10
J= 12	9	8	8	8	9	9	9	9	9	10	10	9	9	10	10	10	10	10	10	10	10	10	9	9	9
J= 11	9	9	9	9	9	9	9	9	9	9	9	8	9	10	9	9	9	9	9	9	9	9	9	9	9
J= 10	9	9	9	9	9	9	9	9	9	9	8	8	8	8	9	8	8	9	9	9	9	9	9	9	9
J= 9	9	9	9	9	9	9	9	8	8	8	8	8	8	8	8	8	8	9	9	10	10	9	9	9	9
J= 8	9	9	9	9	9	8	8	8	8	8	8	8	8	9	8	8	8	9	10	10	10	9	9	9	8
J= 7	9	9	9	9	9	8	8	8	8	8	8	8	9	9	8	8	9	10	10	10	9	9	9	8	8
J= 6	9	9	9	9	9	9	8	9	9	8	9	9	9	9	8	8	9	10	9	9	9	8	8	8	8
J= 5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	9	9	8	8	8	8	8
J= 4	8	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	9	9	9	9	9	8	9
J= 3	8	9	9	9	9	9	9	9	8	8	9	9	9	9	8	9	9	9	9	9	9	9	9	9	9
J= 2	8	9	9	9	9	8	8	8	8	9	9	9	9	9	8	8	8	8	8	8	9	9	9	9	9
J= 1	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9

FIGURE 52

SMOG MODEL O_3 RESULTS, ZERO EMISSIONS RUN
1500–1600 HOURS
8-24-76

SURFACE PRINT OF O3 PPM

MULTIPLIER= 1.00000E-02

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	9	10	10	10	10	10	10	10	10	10	11	11	11	11	10	10	10	10	10	10	10	10	9	10	11
J= 24	9	10	10	11	10	10	10	10	10	10	11	11	11	10	10	10	10	10	10	9	10	9	10	10	11
J= 23	9	10	10	11	10	10	11	10	10	11	11	10	10	10	10	10	10	10	10	10	8	10	10	10	11
J= 22	9	10	10	11	10	10	11	10	11	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11
J= 21	9	10	10	11	11	11	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11	11
J= 20	9	10	10	10	11	11	11	10	10	10	10	10	10	10	10	10	10	10	11	10	11	11	11	11	11
J= 19	9	10	10	10	10	11	11	11	10	10	10	10	10	10	10	10	10	10	11	11	11	12	11	12	12
J= 18	9	10	10	10	10	11	11	11	10	11	10	10	10	10	10	10	10	11	11	11	12	11	11	11	11
J= 17	9	10	10	10	10	10	11	11	11	10	10	10	10	10	10	10	11	11	11	11	10	10	11	10	11
J= 16	10	10	10	10	10	10	10	11	10	10	10	10	10	10	10	11	11	11	11	11	10	11	9	10	10
J= 15	10	10	10	9	10	10	10	10	10	10	11	10	10	10	10	10	10	10	10	10	11	10	11	8	10
J= 14	10	10	9	9	10	10	10	10	11	11	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 13	10	10	9	10	10	10	10	10	11	11	11	10	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 12	9	9	9	10	10	10	10	10	10	10	11	11	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 11	9	9	9	10	10	10	11	10	10	11	11	11	11	10	10	10	10	10	10	10	10	10	10	10	10
J= 10	9	10	10	10	10	11	11	10	10	10	10	10	11	10	10	10	10	10	10	10	10	10	10	10	10
J= 9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11	10	10	10	10	10	10	10	10
J= 8	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	10	10	10	10	10	10	10	10	10
J= 7	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	10	10	10	10	10	10	10	10	10
J= 6	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 5	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 4	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 3	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 2	9	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
J= 1	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	10	10	10	10

FIGURE 53

SMOG MODEL O_3 RESULTS, "CLEAN AIR START" RUN
1000–1100 HOURS
8-24-76

SURFACE PRINT OF O3 PPM

MULTIPLIER= 1.00000E-03

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	46	46	42	41	40	38	36	36	37	38	39	41	43	44	45	45	46	46	44	43	38	46	49	51	52
J= 24	40	45	44	42	42	42	41	40	40	40	39	39	41	42	42	42	43	42	41	32	42	47	50	51	51
J= 23	36	40	43	43	44	45	46	44	44	43	43	42	43	44	44	44	45	43	42	44	34	48	50	51	51
J= 22	36	36	40	44	44	46	47	46	47	46	45	43	44	45	45	44	41	42	43	42	40	50	50	51	51
J= 21	38	35	35	41	43	43	45	46	48	48	46	43	44	44	43	39	40	42	43	44	39	48	49	50	51
J= 20	41	40	37	38	41	40	41	44	48	49	48	44	44	45	42	41	39	40	43	43	45	47	49	49	50
J= 19	41	42	43	42	41	40	40	40	44	50	49	47	46	47	45	43	39	38	41	42	40	45	46	47	48
J= 18	43	43	45	45	44	42	42	42	44	48	49	48	45	47	49	47	39	37	40	41	40	44	44	43	45
J= 17	45	46	47	49	48	45	41	41	42	43	42	44	41	47	47	44	41	39	41	42	39	42	42	41	43
J= 16	44	46	49	50	50	48	44	43	42	43	41	43	43	44	44	43	40	39	41	43	44	39	33	43	42
J= 15	42	43	46	49	48	47	44	40	39	40	38	42	40	42	42	41	38	39	41	43	43	47	49	35	43
J= 14	39	37	38	42	44	42	40	36	37	41	41	43	41	41	40	38	39	39	39	40	40	41	43	50	39
J= 13	38	35	33	34	36	38	35	32	32	40	40	43	42	41	39	39	39	39	40	41	42	44	45	45	49
J= 12	38	43	43	40	41	42	41	37	29	36	42	42	43	44	43	40	38	38	38	39	41	43	46	49	47
J= 11	41	40	41	39	38	42	42	41	35	37	39	42	44	43	43	41	39	37	38	39	41	44	47	48	50
J= 10	42	41	40	42	43	42	44	43	40	35	38	42	43	43	42	41	39	37	37	38	40	44	47	49	49
J= 9	41	40	40	42	45	45	46	46	49	40	34	39	43	43	43	43	40	38	37	38	40	44	47	49	49
J= 8	44	44	44	43	44	46	45	45	47	44	36	38	43	43	44	43	41	39	38	39	41	44	47	48	49
J= 7	44	44	44	45	46	46	47	47	44	44	43	37	42	42	42	43	42	41	39	40	42	45	46	48	49
J= 6	45	45	46	46	46	46	47	47	47	46	44	39	41	43	42	42	42	43	42	42	42	45	46	47	48
J= 5	45	45	45	46	46	46	46	46	46	45	45	42	40	43	44	44	45	45	44	43	43	44	45	46	47
J= 4	46	46	46	46	46	46	47	46	45	45	44	42	38	43	45	47	46	45	44	44	43	44	43	45	46
J= 3	46	46	46	46	46	47	47	46	46	45	44	42	39	40	45	47	49	49	48	45	44	43	44	44	45
J= 2	47	47	48	47	48	48	48	47	47	46	45	44	42	40	44	47	50	51	51	50	48	47	49	46	44
J= 1	48	48	48	48	48	49	49	48	48	47	46	45	44	43	43	48	49	52	52	53	51	50	50	53	49

FIGURE 54

SMOG MODEL O_3 RESULTS, "CLEAN AIR START" RUN
1300-1400 HOURS
8-24-76

SURFACE PRINT OF 03 PPM

MULTIPLIER= 1.00000E-03

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	42	40	41	44	50	54	57	58	56	58	56	52	48	45	44	42	41	40	41	44	43	49	48	48	45
J= 24	44	39	40	43	49	53	56	57	57	56	58	56	53	48	45	43	43	39	39	39	41	50	47	43	42
J= 23	43	40	42	45	50	53	56	57	58	53	60	58	54	49	46	44	40	40	39	39	40	47	45	43	43
J= 22	42	42	41	42	46	51	56	61	60	58	60	54	50	46	43	42	39	39	41	39	42	45	46	44	44
J= 21	42	41	40	38	41	47	55	62	64	59	55	49	47	44	43	41	40	40	40	40	40	48	48	43	43
J= 20	43	41	41	38	41	47	53	63	64	56	47	44	42	41	40	39	41	42	43	39	42	42	42	36	41
J= 19	43	41	40	42	41	44	47	59	58	47	44	42	42	42	38	37	39	42	44	42	43	42	42	41	44
J= 18	43	42	40	40	40	39	41	52	47	46	45	43	42	39	40	38	43	45	47	46	49	45	49	50	48
J= 17	43	42	40	40	39	40	43	42	43	44	43	42	37	38	42	45	47	50	52	57	47	50	47	45	45
J= 16	44	43	41	40	38	39	39	41	42	43	41	40	39	43	48	50	50	49	49	47	46	46	40	45	45
J= 15	46	47	43	40	39	37	39	46	44	42	38	40	40	43	46	48	48	47	47	46	46	42	45	38	43
J= 14	44	49	45	42	38	39	43	42	44	46	48	48	49	48	49	48	48	48	47	49	43	40	40	40	42
J= 13	46	46	40	37	36	40	41	42	43	48	46	44	43	43	43	46	48	50	52	45	43	41	40	40	42
J= 12	44	41	37	38	38	40	42	47	42	43	39	37	37	38	40	44	47	51	47	44	42	41	41	39	40
J= 11	45	40	39	38	39	40	39	39	36	36	36	39	42	42	42	42	50	49	46	44	43	41	41	39	39
J= 10	43	41	40	38	43	44	42	40	39	38	39	41	43	40	44	48	50	50	47	44	43	41	40	39	39
J= 9	43	42	40	40	48	47	44	40	39	38	39	44	43	46	49	50	49	50	48	46	44	42	41	39	39
J= 8	43	42	40	41	47	47	44	41	39	40	43	48	51	53	52	51	50	48	48	47	46	43	41	39	39
J= 7	43	42	40	44	44	43	42	40	41	43	48	49	52	53	52	50	50	48	53	52	48	44	42	39	40
J= 6	44	42	42	41	42	43	40	42	45	47	51	51	52	52	49	49	50	53	55	51	46	43	41	40	41
J= 5	45	44	45	45	47	43	43	46	48	50	51	52	52	51	48	49	52	54	53	49	46	44	43	41	42
J= 4	43	41	41	42	41	44	46	49	50	50	51	52	51	50	47	50	52	53	49	47	47	46	45	44	44
J= 3	43	42	40	42	47	49	49	50	50	50	50	49	50	47	45	49	49	48	45	45	47	47	48	46	45
J= 2	44	41	43	46	48	48	48	48	49	48	47	48	46	46	45	47	45	43	44	45	46	47	48	49	48
J= 1	45	46	46	47	46	46	46	47	47	46	45	45	44	45	44	43	44	45	45	45	45	47	48	51	51

FIGURE 55

SMOG MODEL O_3 RESULTS, "CLEAN AIR START" RUN
1600–1700 HOURS
8-24-76

SURFACE PRINT OF O3 PPM

MULTIPLIER= 1.00000E-03

I=	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
J= 25	41	38	34	32	30	29	32	30	30	29	27	24	23	21	21	20	20	19	20	20	23	22	22	23	24
J= 24	40	37	31	27	25	25	31	31	35	31	26	22	20	19	19	19	19	16	20	19	22	23	24	25	25
J= 23	40	36	30	26	25	26	29	29	36	29	22	21	20	20	20	20	17	17	20	19	21	23	25	25	25
J= 22	40	35	26	23	23	25	28	30	33	25	21	21	20	20	20	19	17	18	19	21	22	22	25	25	25
J= 21	39	33	22	21	22	23	25	31	28	25	21	22	22	22	21	17	18	18	21	22	21	24	26	24	23
J= 20	38	30	24	20	21	20	25	26	33	29	21	25	22	22	18	18	18	16	21	23	24	25	26	23	22
J= 19	37	30	26	24	20	20	21	25	33	31	22	27	24	21	18	18	19	19	23	25	26	26	25	24	24
J= 18	39	32	25	20	18	18	19	20	24	31	25	25	22	19	20	21	21	23	25	28	26	26	26	24	24
J= 17	38	30	23	20	19	19	17	19	21	20	23	23	19	22	22	22	24	25	26	24	22	21	21	21	23
J= 16	37	29	22	19	18	18	16	19	22	21	20	22	24	22	21	22	23	22	21	24	24	24	21	25	23
J= 15	35	26	21	18	18	17	18	20	19	18	18	24	21	21	21	20	20	21	25	25	26	24	24	20	21
J= 14	34	25	20	18	18	17	18	18	17	20	22	22	20	21	23	23	25	29	29	28	26	24	24	23	22
J= 13	33	24	20	18	18	17	20	19	17	19	19	19	18	22	24	29	33	32	31	29	27	26	24	22	22
J= 12	33	26	22	20	20	21	24	28	18	19	18	18	19	25	33	37	37	36	36	33	29	25	23	21	21
J= 11	36	29	24	21	20	23	25	22	19	20	19	19	23	28	37	40	46	46	39	32	27	24	22	21	20
J= 10	38	31	26	23	23	26	25	22	20	19	18	17	23	30	41	48	48	41	34	29	26	24	22	21	20
J= 9	38	32	27	24	25	24	23	21	20	19	17	19	25	31	42	42	42	38	34	30	26	23	22	20	20
J= 8	39	32	28	25	24	24	22	21	20	20	18	19	24	35	39	38	42	36	35	30	26	23	21	20	20
J= 7	39	32	28	25	25	23	21	21	21	21	20	21	28	33	37	38	43	40	34	28	24	22	21	20	20
J= 6	39	33	28	25	24	22	22	22	23	22	21	24	29	34	36	34	38	35	29	25	23	22	22	21	21
J= 5	40	33	29	26	25	24	24	24	25	23	23	26	30	32	32	37	38	33	29	28	27	25	24	22	21
J= 4	38	32	28	27	27	26	27	27	28	25	26	30	32	32	36	33	36	35	33	32	30	27	25	23	22
J= 3	39	34	32	31	31	31	31	30	31	29	31	33	35	35	34	36	37	35	34	33	31	29	27	25	23
J= 2	40	37	36	35	35	35	35	35	36	35	35	37	37	37	37	36	38	38	38	37	35	33	30	27	24
J= 1	42	41	41	41	41	41	41	41	41	40	41	41	41	42	38	40	40	40	40	40	39	38	36	33	28

FIGURE 56

WIND FLOW FIELD - SACRAMENTO REGION

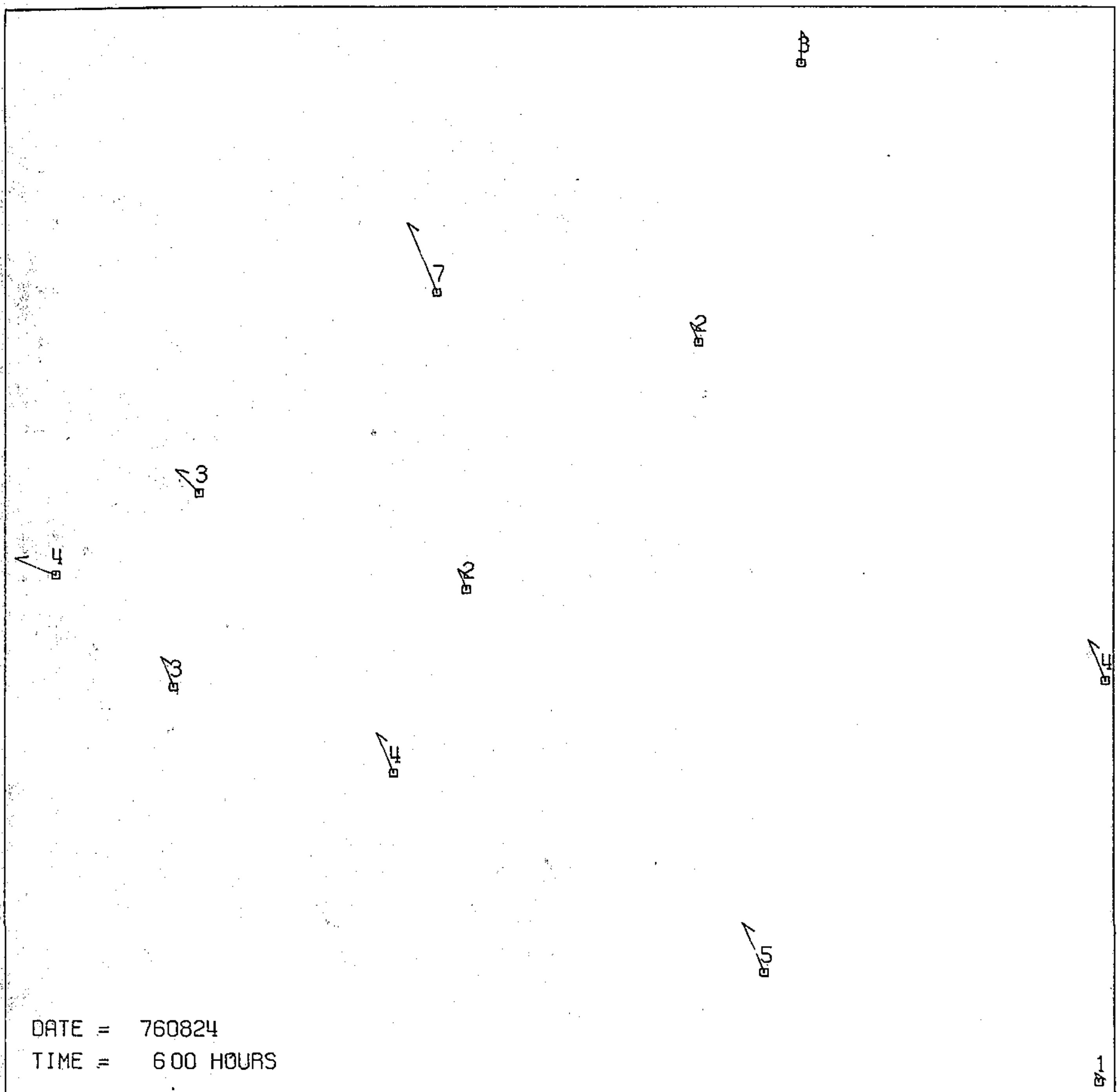


FIGURE 57

WIND FLOW FIELD - SACRAMENTO REGION

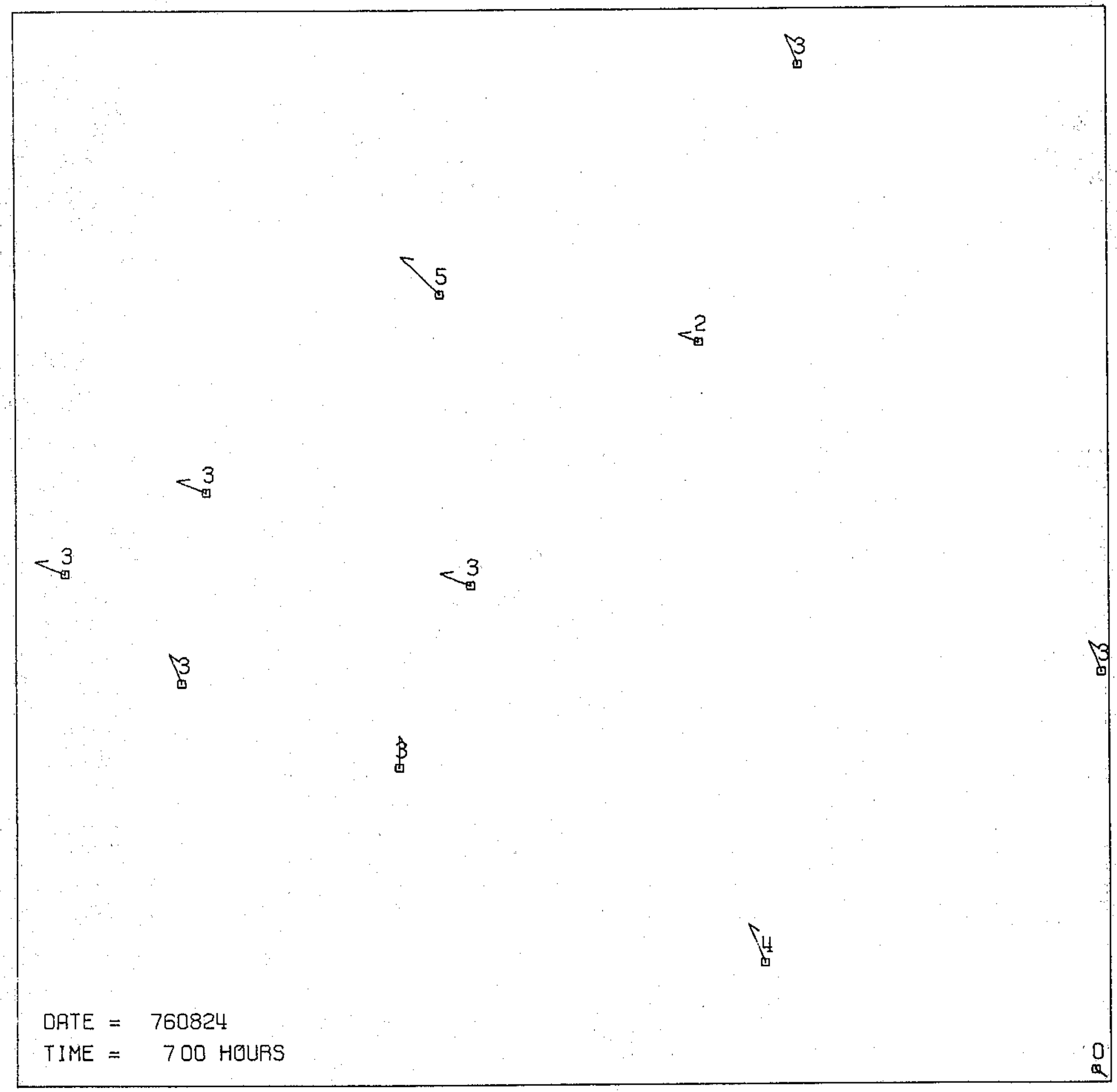


FIGURE 58

WIND FLOW FIELD - SACRAMENTO REGION

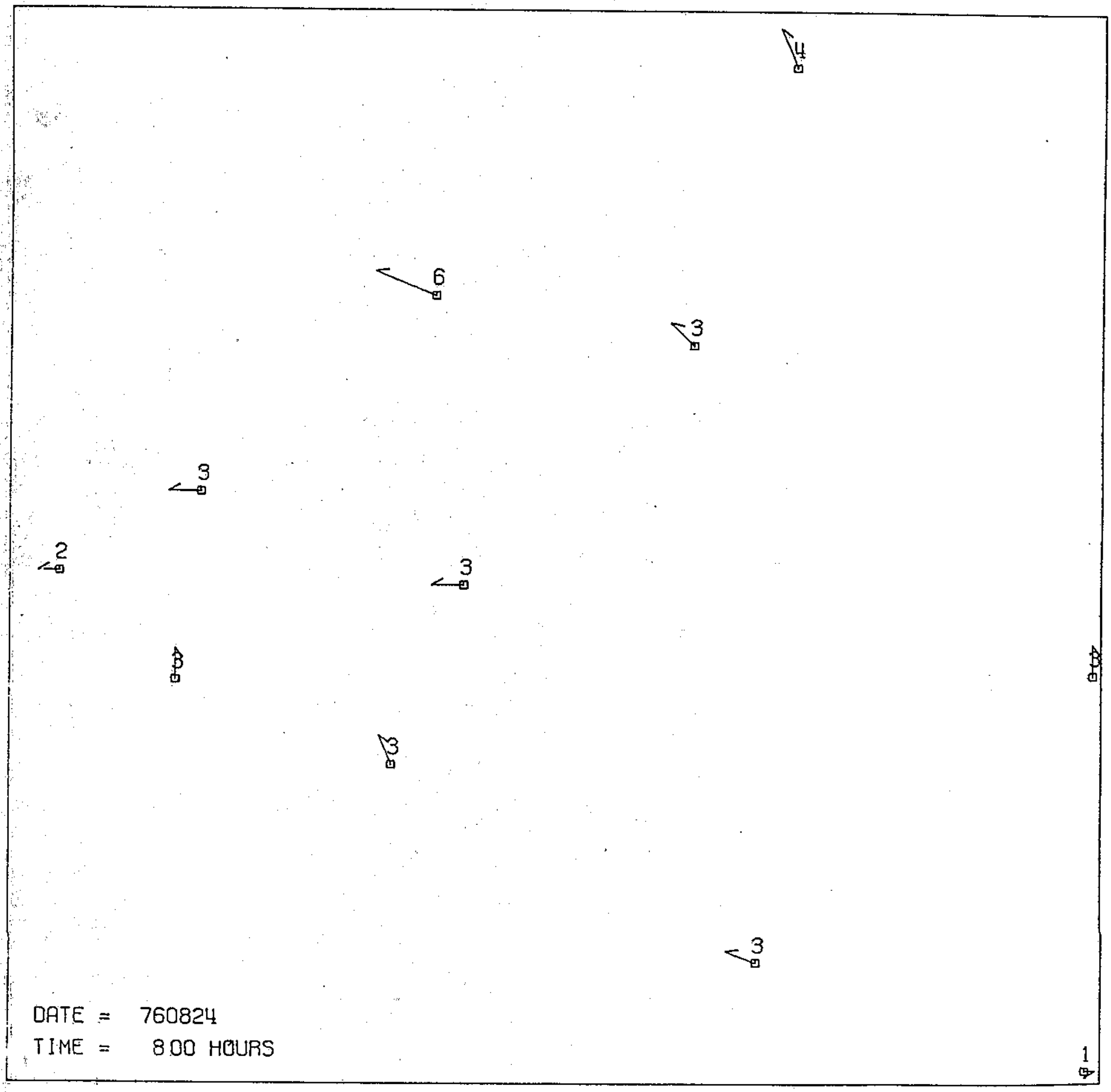


FIGURE 59

WIND FLOW FIELD - SACRAMENTO REGION

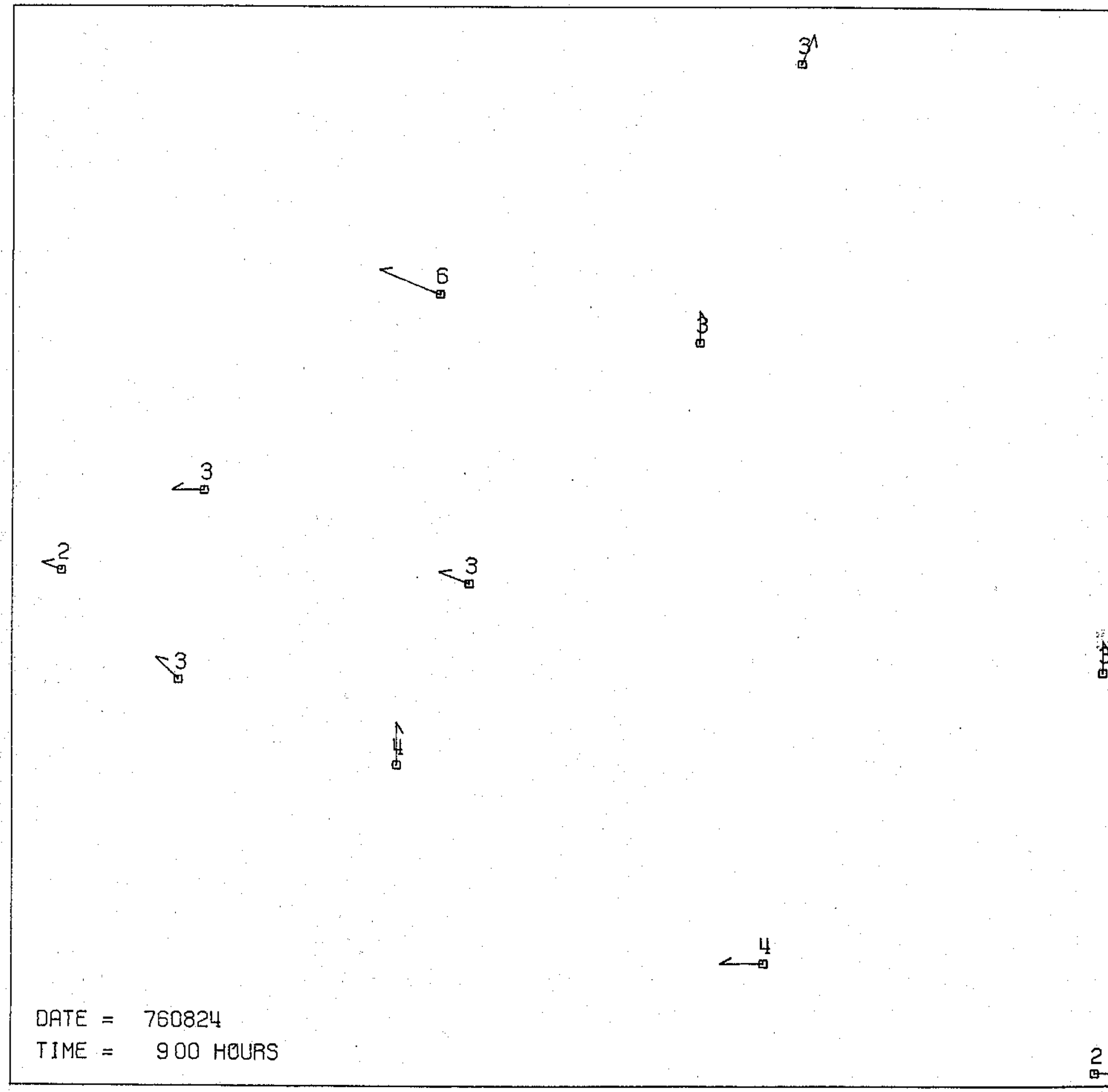


FIGURE 60

WIND FLOW FIELD - SACRAMENTO REGION

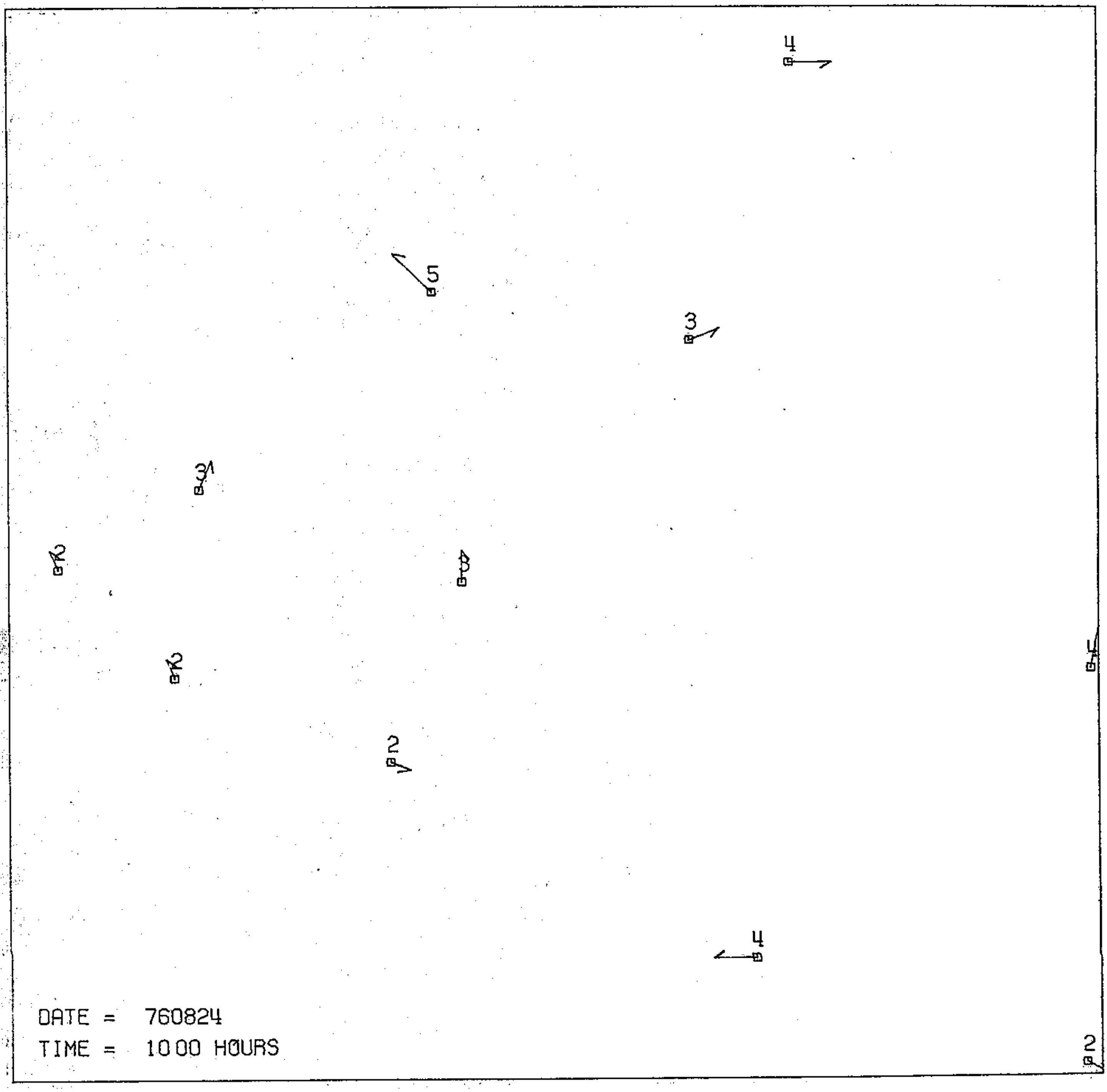


FIGURE 61

WIND FLOW FIELD - SACRAMENTO REGION

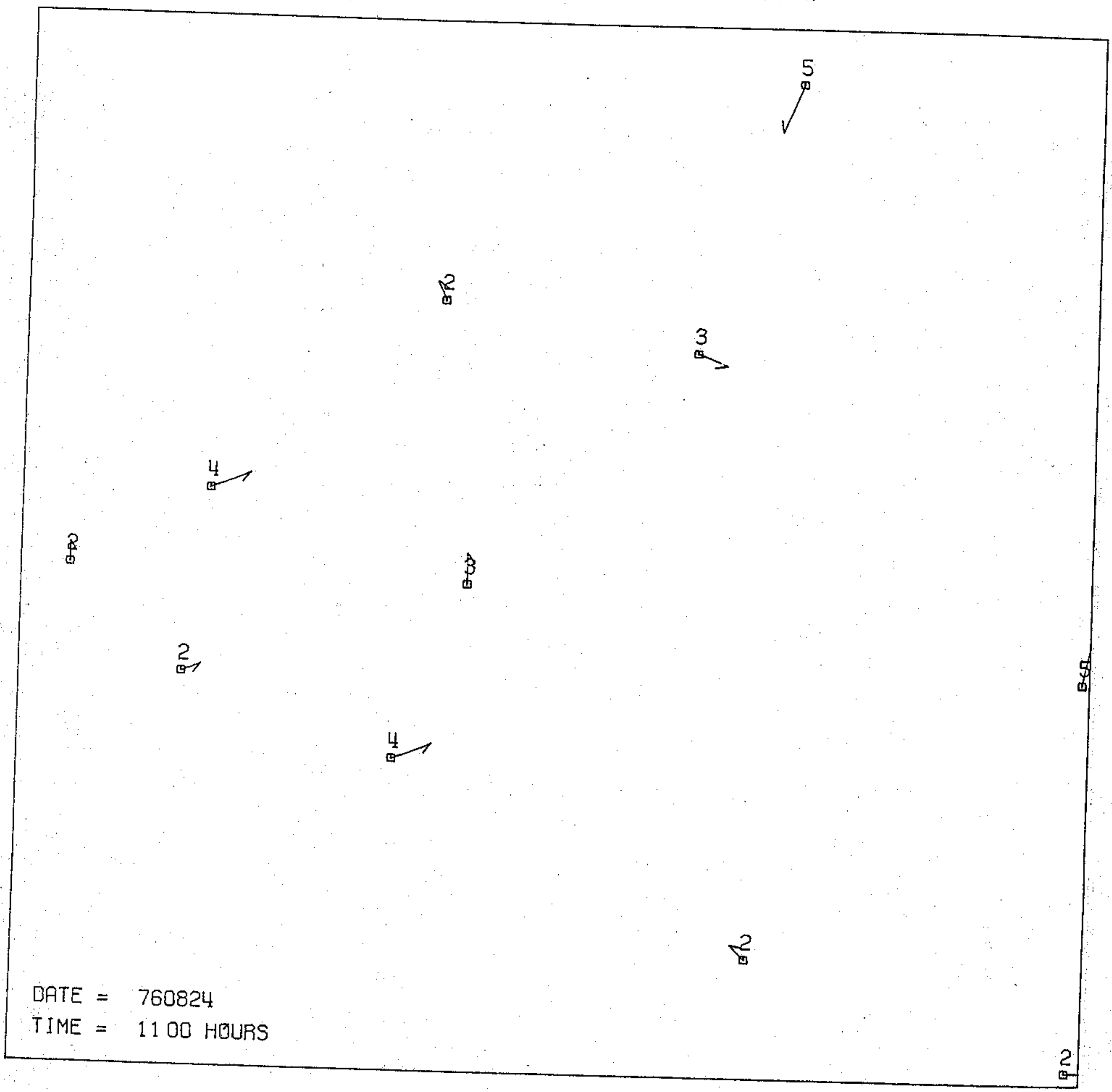


FIGURE 62

WIND FLOW FIELD - SACRAMENTO REGION

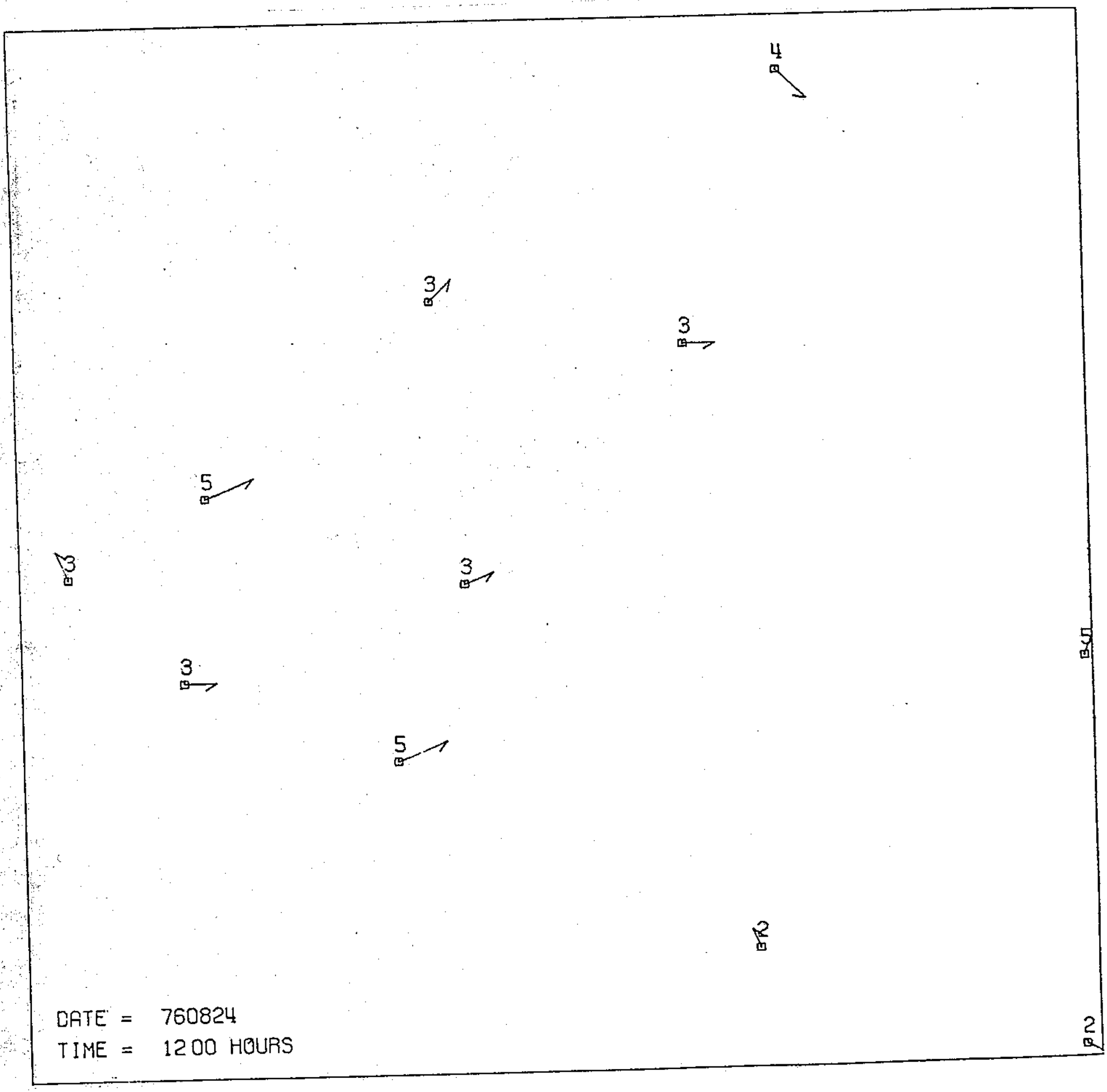


FIGURE 63

WIND FLOW FIELD - SACRAMENTO REGION

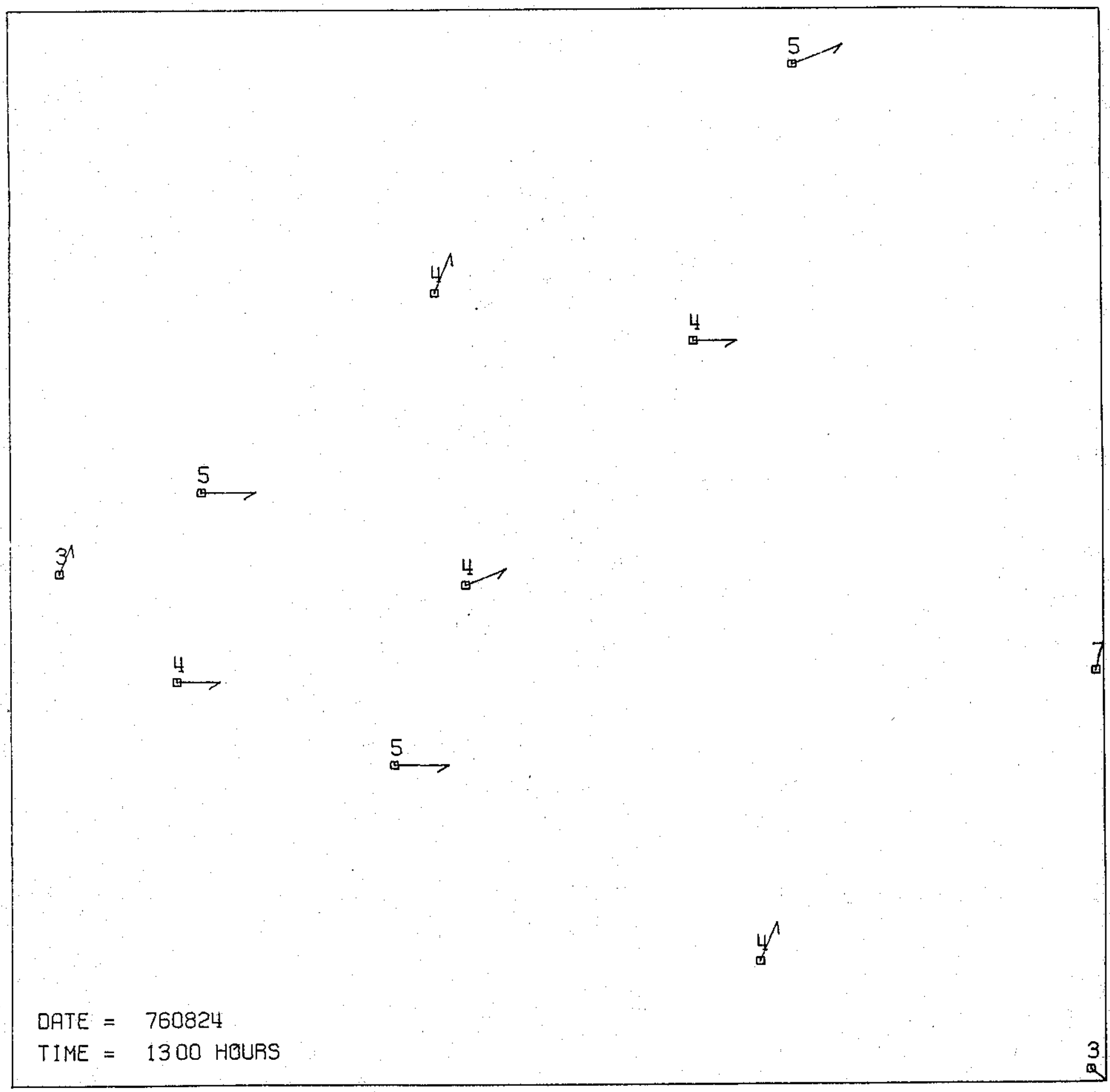


FIGURE 64

WIND FLOW FIELD - SACRAMENTO REGION

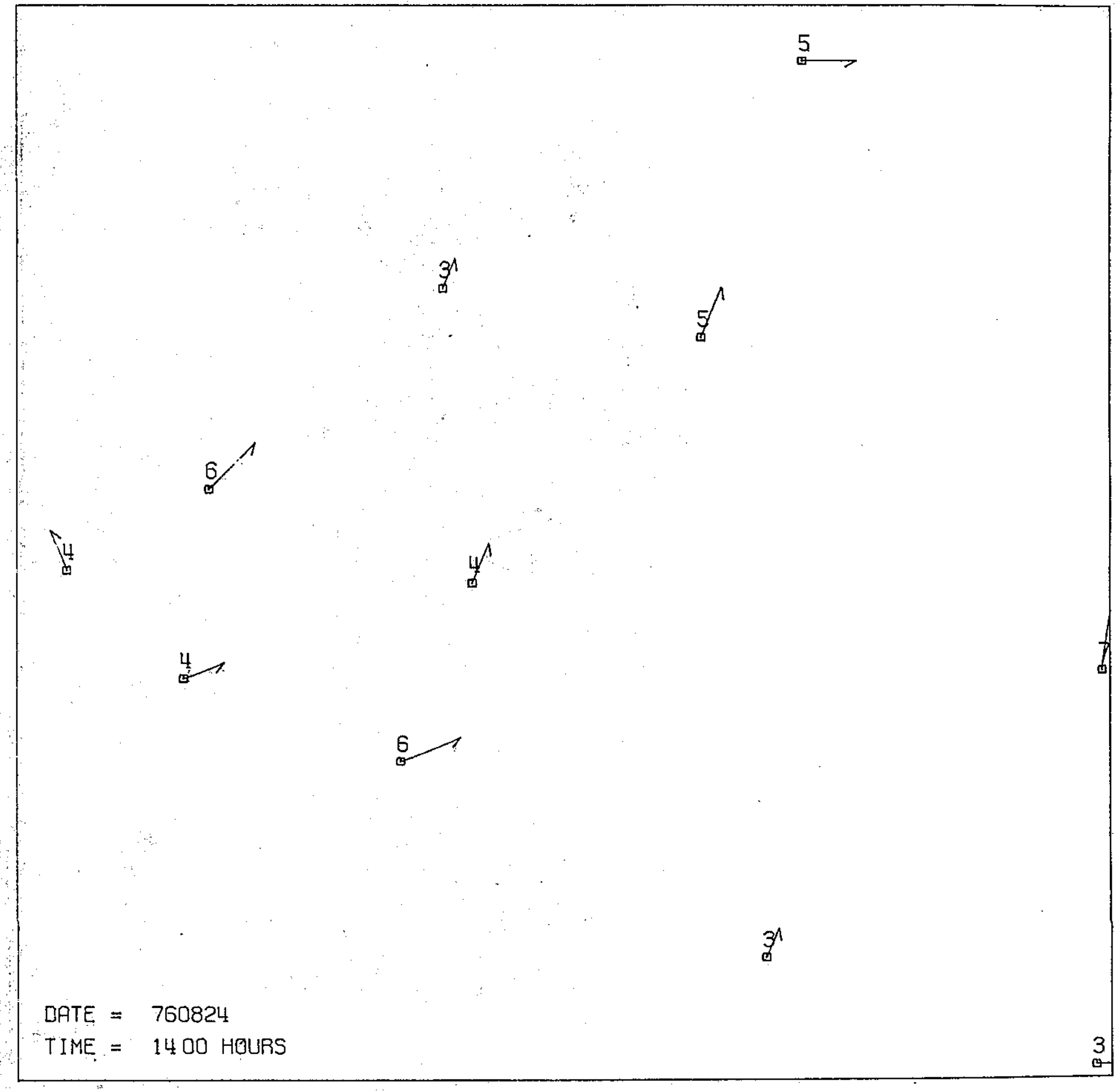


FIGURE 65

WIND FLOW FIELD - SACRAMENTO REGION

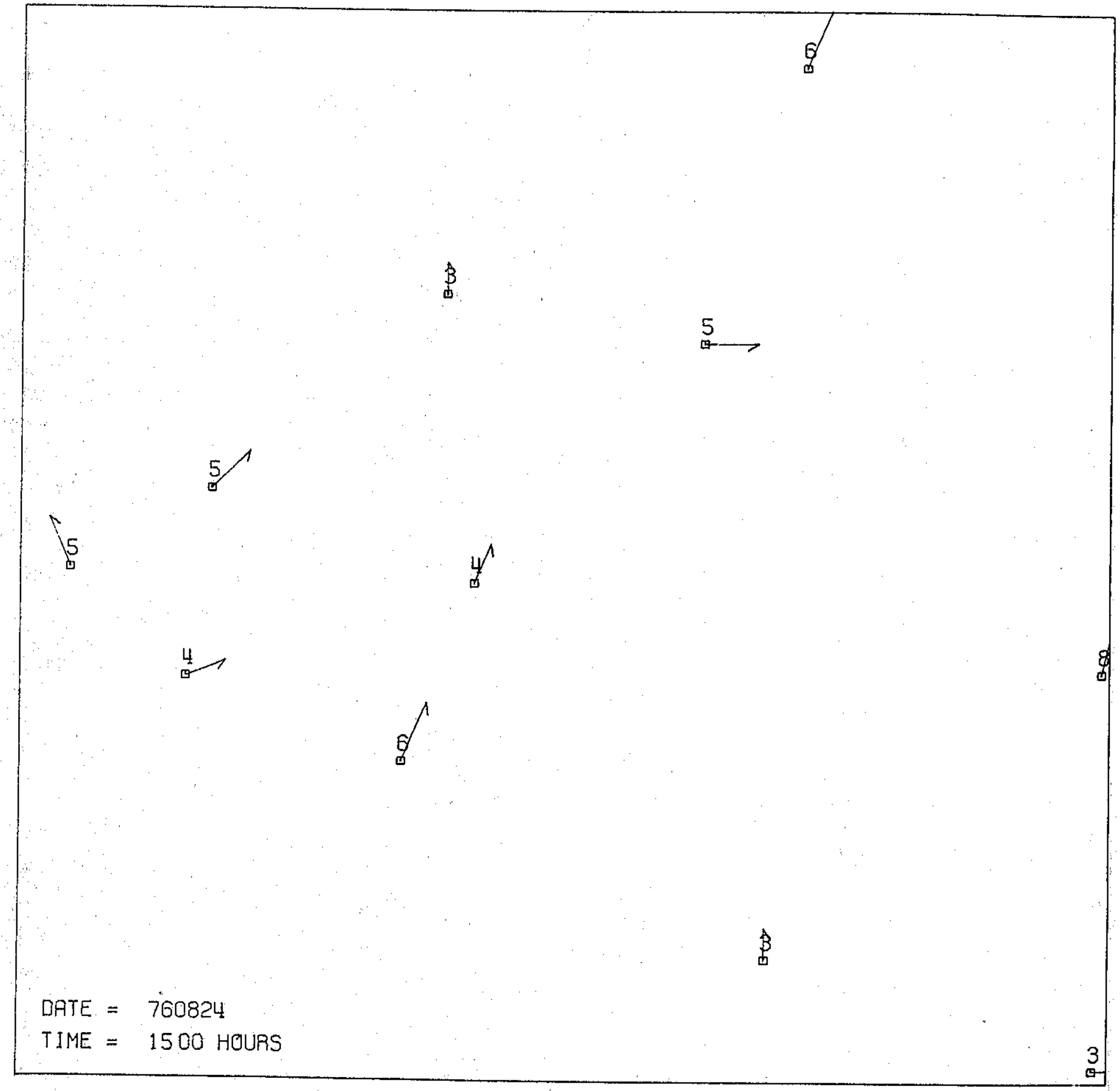


FIGURE 66

WIND FLOW FIELD - SACRAMENTO REGION

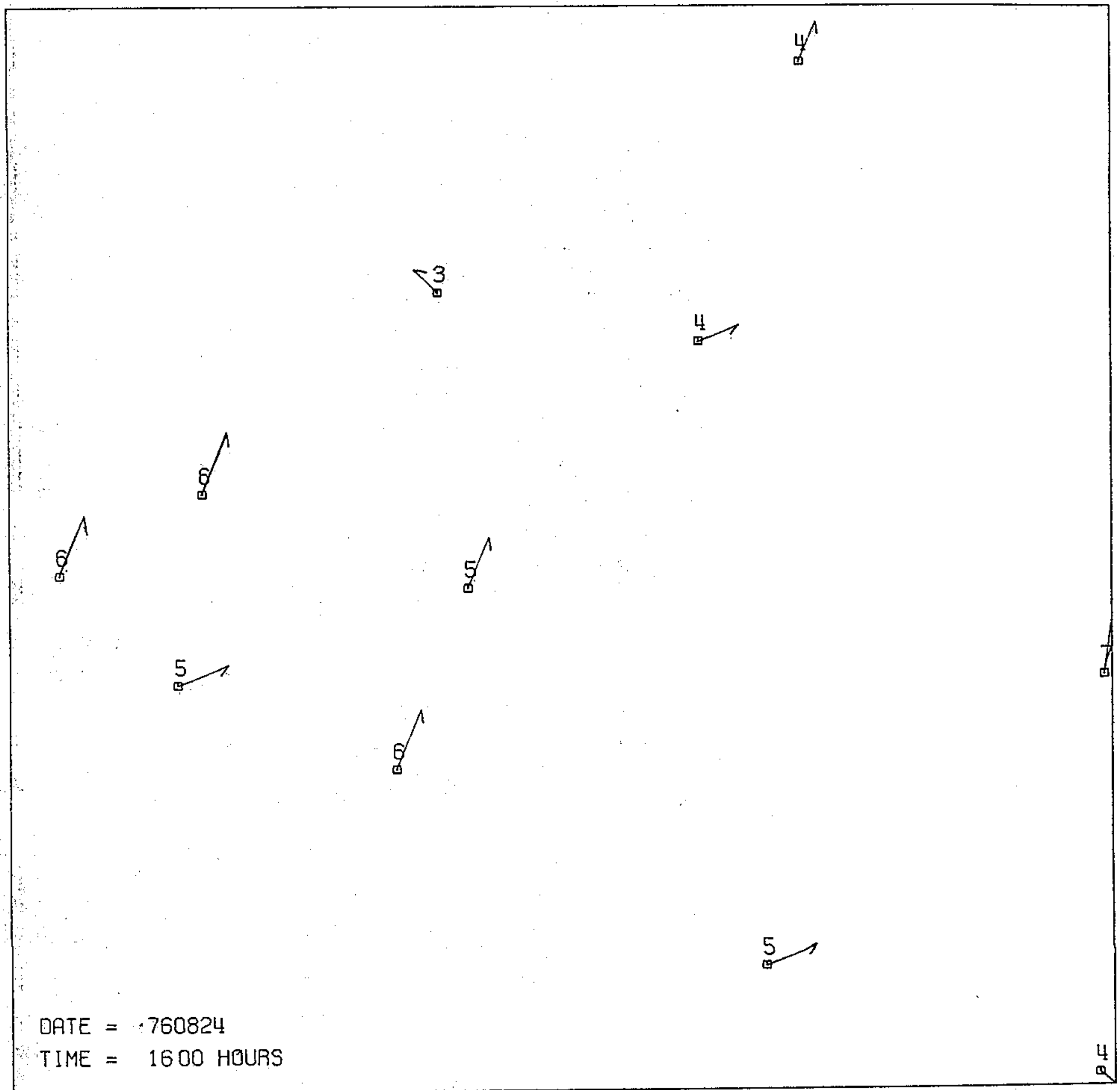


FIGURE 67

WIND FLOW FIELD - SACRAMENTO REGION

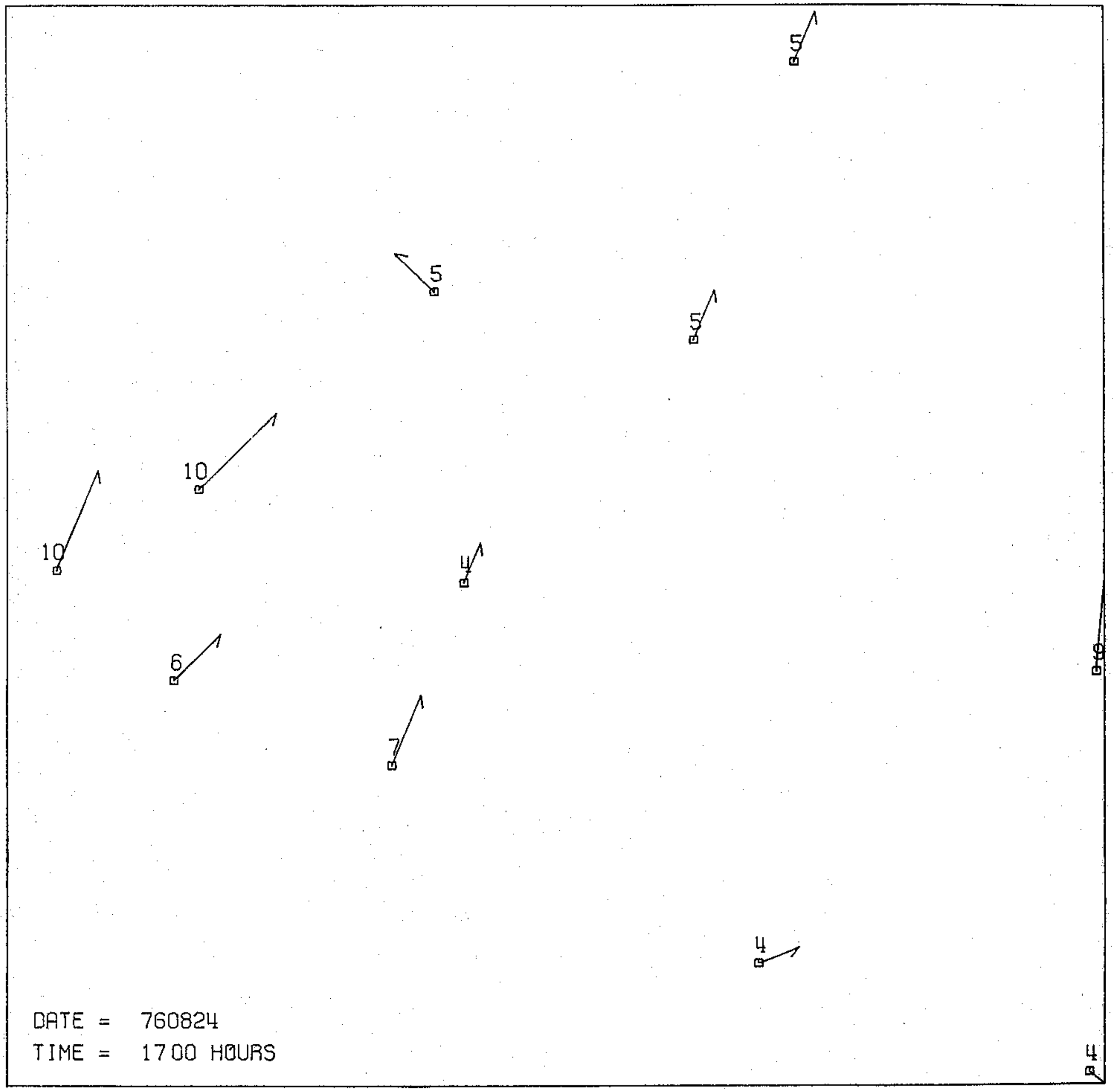


FIGURE 68

WIND FLOW FIELD - SACRAMENTO REGION

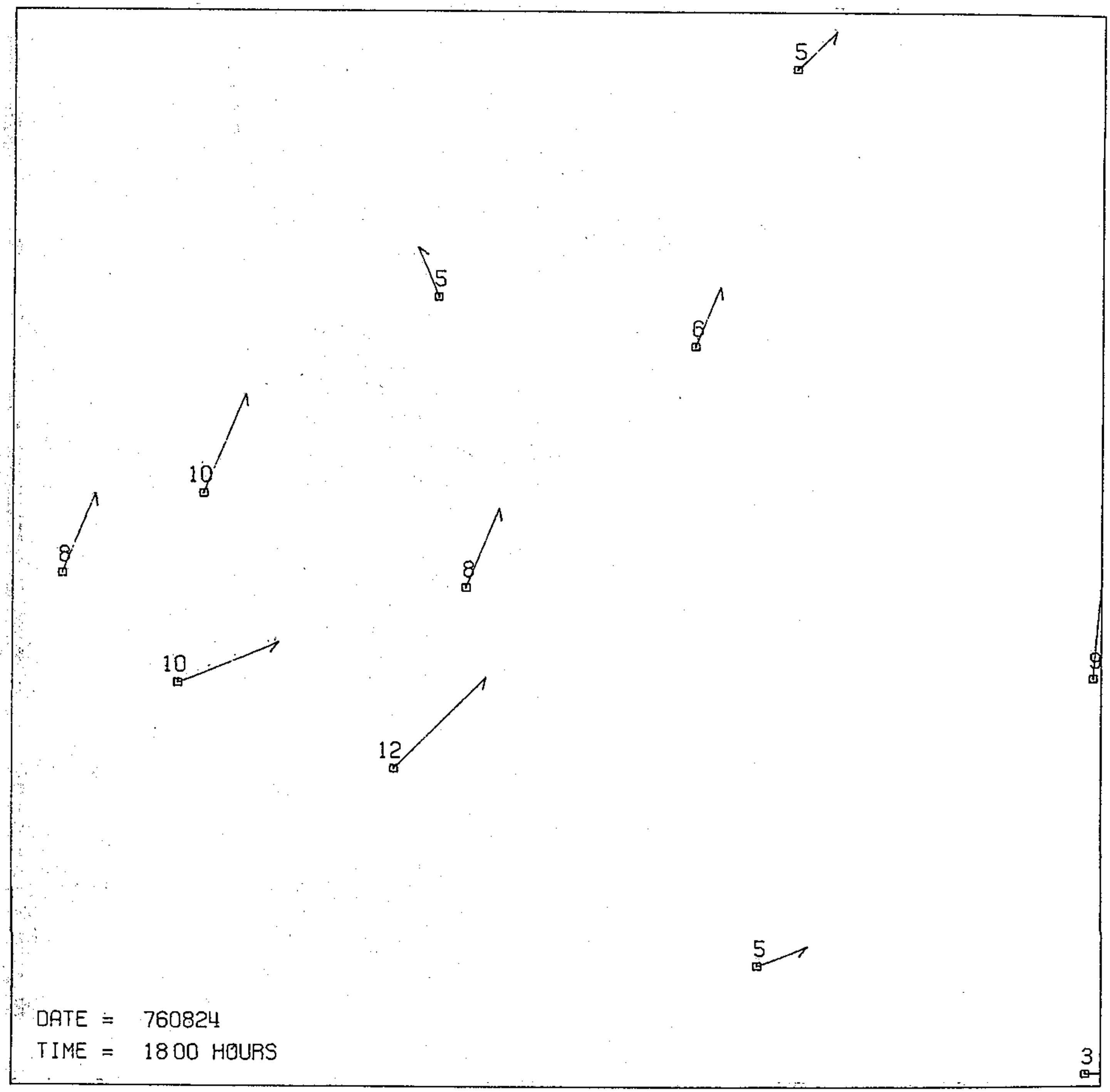


FIGURE 69

FAVORABLE AND UNFAVORABLE ASPECTS OF THE SAI 15-STEP CHEMISTRY AND SMOG MODELS

SAI Favorable

1. Fewer than 625 grid squares can be used and the study area as a whole does not need to be rectangular. This means that the study area can be tailored to fit the area of most interest, and computer expenses can be saved by the elimination of unnecessary grid squares.

2. Wind flow fields for each modeling hour are available prior to the air quality simulation program run.

SAI Unfavorable

1. The chemistry algorithms are outdated and Caltrans Laboratory personnel were unable to effect a verification.

2. The nighttime phenomenon of low ozone concentrations on the ground and higher ozone concentrations above the 250 to 500 foot elevations is well known. It is, however, difficult or impossible to simulate with the SAI model because only one vertical cell is allowed in the simulation "box". The only available inputs relating to concentrations aloft are the "CALOFT" parameter which is fixed in altitude and pollutant concentrations for the entire simulation period and the mixing depth parameter which can change the inversion height elevation each hour but will not affect the pollutant concentrations.

3. As many as five preparatory programs are necessary, whereas the SMOG model requires none. This requirement raises the labor costs for performing a photochemical model run with the SAI model.

4. The region size can be no larger than 25 grid squares per side.

5. The SAI model cannot distinguish between "zero pollution concentration" and "station not operating". For this reason, it assumes that a zero input reading means "station not operating", and in order to input a zero reading a very low concentration must be used. For example, if a CO reading of zero is observed, it must be input to the SAI model as 0.1 ppm or at least something less than the minimum reading made by the monitoring equipment.

6. No reactive hydrocarbon species splits can be defined. The user can make one input of unreactive hydrocarbon concentration and one input of reactive hydrocarbon concentration. No identifications of olefins, aromatics, paraffins, or aldehydes are allowed.

SMOG Favorable

1. The model has a more up-to-date chemistry, and the Caltrans modelers have been able to effect a verification for ozone.

2. The inputs have options with regard to the types of plume rise and diffusivity algorithms desired. Many temporal output options are available.

3. The hydrocarbons are input by lumped species.

4. The thickness and size of vertical cells are variable. Thus a vertical concentration and wind profile can be easily established.

5. There is no limit on the lengths of the sides of the study area (within economic feasibility).

6. Ancillary programs such as a plot of wind flow fields are easily prepared and accessed.

SMOG Unfavorable

1. A rectangular study area is required. Thus computer time is often expended to study areas of non-interest.

POTENTIAL TRANSPORT STUDY

The question of how much pollution is generated in the Sacramento region and how much is advected from the Bay Area has been actively discussed over a considerable period. That such a phenomenon did occur during the period July 14-15, 1972 has been documented (18). Ozone levels of 0.29 ppm in the Bay Area on July 14 resulted in ozone levels of 0.21 ppm in Sacramento the next day.

Tables 7 and 8 compare ozone readings for the candidate days at various Sacramento River delta stations with the readings in the study area. They contain no evidence that high ozone days in Sacramento were preceded by high ozone concentrations in the delta. The delta stations are generally upwind from Sacramento.

One could conclude that the transport is minimal; however, the readings are exclusively on the ground, and surface pollutant levels can decay by scavenging due to various chemicals and due to deposition as the air comes close

TABLE 7

Maximum surface ozone readings upwind of Sacramento Region (PPM)

Location	June 27	June 28	Aug 23	Aug 24	Aug 26	Aug 27
Concord	.08	-	.08	.07	.07	.07
Vallejo	.04	.04	.05	.04	.07	.06
Fairfield	.06	.14	.04	.06	.07	.08
Rio Vista	-	-	.04	.06	.04	.07
Davis	.07	.05	.05	.07	.04	.06
Pittsburg	.15	.15	.04	.05	.06	.13

TABLE 8

Maximum surface ozone readings in the Sacramento Region (PPM)

Location	June 27	June 28	Aug 23	Aug 24	Aug 26	Aug 27
Meadowview	-	-	.08	.09	.05	.09
Northgate	.08	.16	.07	.12	.03	.09
Roseville	.05	.11	.06	.13	.06	.08
Downtown ARB	.08	.13	.06	.09	.04	.08
Creekside APCD	.07	.16	.07	.13	.05	.13

to the ground. It must therefore be concluded that this research project did not determine the presence or lack of significant pollutant transport in the metropolitan Sacramento area.

In order to study the transport of pollutants into the Sacramento region, a study on the order of the ARB's current San Joaquin Valley study is probably necessary.* At the minimum, one would have to establish monitoring stations in the delta and the Fairfield areas, have wind stations from Vallejo to Sacramento, and do frequent flying in aircraft equipped with pollutant monitoring devices to determine if transport of pollutants at levels above the ground is an existing phenomenon.

The plan might take shape something like this. Establish the windflow fields for the delta and Sacramento areas with an approximate boundary from Pittsburg to Vallejo to Fairfield to Vacaville to Woodland to Roseville to Rancho Seco to Lodi and finally back to Pittsburg. Then study this area as intensively as funding allows with regard to the ground pollutant concentrations under various wind regimes. Furthermore, fly aircraft through the area in such patterns that pollutant concentrations aloft can be determined under the various wind regimes. Given these data, it is believed that the impact of transport of pollutants into the Sacramento region could be studied using regional ozone modeling.

*A comprehensive study of pollutant transport in the San Joaquin Valley is scheduled to be completed in 1981. The California Air Resources Board is the project originator and their contractors include Meteorology Research, Inc., Environmental Research and Technology, California Institute of Technology, and Rockwell International Corporation.

APPLICATION OF THE SMOG MODEL'S FINDINGS AND POTENTIAL USES

The results of this study indicate that the SMOG model can predict the ozone concentration in the Sacramento region over a short period of time. The model can therefore be applied to a situation where an agency wants to know the level of ozone that can be anticipated in the afternoon of a specified day, given the wind regime and the initial concentrations for early in the morning of that day. The study indicates that the ozone predictions will be correct within a range of ±25%.

There are indications that the model can generate accurate episodic ozone concentrations from so-called "clean air" using the meteorology regime and the emissions data base from a region. It has been shown that, in a 13-hour simulation, air with an ozone concentration of .01 ppm can be taken to the .05 ppm level given a meteorologic regime conducive to the propagation of ozone. However, to reach episodic levels, the ozone generation must be over at least one night and perhaps more than one night. Along with the problem of obtaining funding for such simulations, the question of the atmospheric chemistry being valid through a nighttime period is also unresolved.

Inasmuch as when all emission sources were turned off, the ozone concentration fell only .01 ppm, it is evident that the SMOG model is not sensitive enough to be used in the regional evaluation of a single point source or highway project alternatives. Likewise, traffic planning decisions such as the use of buses as opposed to new freeway lanes and temporal changes like the staggered work time concept cannot be evaluated using the model. The practical application of the SMOG model, at present, is limited to the aformentioned intra-day prediction of hourly ozone concentrations.

Additional work involving simulations over extended periods should be done to determine the model's potential for evaluating the pollution concentration buildup in an area with and without a specific emission source.

PROBLEMS AND UNCERTAINTIES IN MONITORING AND MODELING

1. State of the Science/Art

The fact that the science of regional ozone modeling is in a state of flux is perhaps the most important problem. As an example, when this research project was initially proposed in 1973, the SAI 15-step 25x25 regional airshed model was designated as the model to be used. When the modeling actually began in 1977, MAQU recommended the SMOG model. During the period of time from 1973 until the present, SAI improved their regional ozone model several times.

It was a major decision on the part of the investigators to abandon further testing of the SAI 15-step chemistry model and go to the SMOG model. Indeed, some simulation trials with the SAI model were consummated, and a section of this report deals with those trials. At the present time, SAI's latest model with the 38-step carbon-bond-mechanism is claimed by SAI to be the state of the art;

the SMOG model has proven to modelers of the ARB and Caltrans that it is capable of predicting ozone to the point of achieving a verification in a region; the LIRAQ model (19) for the San Francisco Bay Area and the MADCAP model (20) in the San Diego area are in current use; and a new model with advanced chemistry is in the final stages of development at the California Institute of Technology.

The problem then is to choose a model for one's particular region which will provide adequate results. But since this research shows that the existing regional ozone models are not able to answer transportation planners' questions such as the effect of locating or relocating sources within a study region, it is recommended that the maximum possible amount of flexibility be incorporated into the computer modeling stage of any project so that any late improvements in computer modeling technology might be incorporated into the study.

2. Emissions

An emissions inventory is at best a guess. Just as the census takers can never be sure that they have counted everybody, the assembling of an emissions inventory is an estimate. Intuitively it can be concluded that the emissions tally is probably short. The mobile emissions estimate is likely more accurate than the stationary emissions estimate because the traffic counts are made with reasonable accuracy, while the manufacturing and product consumption processes in domestic and business life that release hydrocarbons are much more difficult to quantify. Examples of important sources that fall into the latter category include household use of aromatics, agricultural burning, and backyard bar-b-que cooking. The importance of inaccuracies in the stationary emissions inventory, however, are relatively unimportant in comparison with problems involved in correctly simulating atmospheric chemistry.

Other potential sources when discussing emissions are those from vegetation, particularly conifers. Although the EPA minimizes the importance of reactive hydrocarbons emanating from vegetation, considerable evidence exists that the thicker vegetative covers which grow in periods of heavy rainfall emit terpenes. These hydrocarbons, if actually present, would result in higher generation of ozone after wet winters than one might observe in years with lighter vegetative cover.

Any discussion of pollutant emission uncertainties should include the fact that automobile emission technology is changing rapidly. Auto emissions are scheduled to decrease through the next decade, but there is a chance that they may increase if public demand for more fuel economy becomes more important than the demand for clean air.

3. Incomplete Data Base

It is important for model verification and simulation runs that the modeler have confidence in his air quality data base; and, with limited funding, it is quite likely that the modeler will not have all the air quality monitoring facilities that he might wish. In the case of the Sacramento study, a region of 2500 square kilometers was represented by fewer than 10 air quality monitoring stations, and the wind-flow regime was developed on the basis of a similar number of meteorological sensing devices.

In rural areas the importance of intensive air quality monitoring is not so great as in the urban areas. In the urban areas where major emission sources exist, large gradients in air quality concentrations can occur within one grid square; indeed within a few city blocks. Developing the air quality concentrations in a urban area is very complex; and here, perhaps, is an instance where fewer monitoring stations are preferable to many. The reason for this might be that many monitoring stations would provide such variations in concentrations due to proximity to major sources that it would be difficult to arrive at a satisfactory estimate. Furthermore, even when gradients within grid squares are recognized in the urban areas, the model provides no means with which to enter these microscale gradients. They must be averaged within the minimum size area considered by the model which is the single grid square.

Another area where necessary estimating results in a confidence problem is in the height of the temperature inversion or the mixing depth level. Usually the temperature inversion height is determined by airplane temperature flights or the use of an acoustic sounder. The typical project budget allows one acoustic sounder for the entire region, and the airplane flights are so costly that only one or two parts of the region can be measured three times per day. This results in the necessity of estimating the inversion height for much of the areal and temporal extent of the ozone modeling.

4. Recovery of Data

Although the reliability of individual monitoring devices was satisfactory, and the simultaneous breakdown of the instrumentation was not common, it was the experience of the researchers on this project that 50%-65% recovery of truly reliable data can be expected on average. This indicates there will be significant gaps in the data due to editing of faulty data or because of periods where the equipment was not operating. During the gathering of the Sacramento data base, the greatest loss of data occurred in air quality monitoring; however, the battery driven anemometers and wind vanes of the meteorological sensors also were inoperative a minor percentage of the time.

5. Vertical Resolution

In the Sacramento area no monitoring of air quality above the ground surface was performed, so all concentrations of pollutants for the vertical cells had to be made by estimations based on information from the literature and from experience in air quality sampling aloft in the Bakersfield area. Similarly, the surface wind regime is well delineated, but the wind regime in the upper level cells is partly an estimate since the use of pilot balloons to determine upper level winds was seldom more frequent than once per day. The stability classes aloft were estimated by engineers, but "power law" calculations built into the SMOG model were used to estimate the speed of the upper level winds.

6. Computer Expenses

The 1979 computer cost (based on lowest "week-end" Teale Data Center rates) for executing the SMOG model is about $50 per simulation hour. A thirteen hour simulation has run $600 to $800. The budget allotment for computer time was too little to allow much flexibility in developing a pattern of computer runs for verification. Results of certain runs suggested that additional simulations should be performed to enlarge upon knowledge gained during these runs. Although it is hoped that a parallel project can be pursued in the future, lack of funding prevented immediate follow-up on the information.

7. Determination of Pollutant Transport

Reaching conclusions on the role of transport of air pollutants into the study region was stymied by lack of upper air pollutant concentration data. An apparent key factor in estimating the transport of pollutants into a region is being able to use aircraft to measure the pollutants carried by prevailing winds. This was not done, so the project ended with the impression that transport into the Sacramento region is probably an important air quality problem but requires much additional evaluation.

REFERENCES

1. Reynolds, S. D., et al, "Development of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants - Final Report," Systems Applications, Incorporated, San Rafael, California, November 1971, et seq. See Appendix A.

2. Hecht, T. A., and Seinfeld, J. H., (1972), "Development and Validation of a Generalized Mechanism for Photochemical Smog," Environ. Sci. Technol., Vol. 6, No. 1, p. 47-57.

3. Eschenroeder, A. Q., Martinez, J. R., and Nordsieck, R. A., "Evaluation of a Diffusion Model for Photochemical Smog Simulation," EPA-R4-73-012a, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (1972).

4. Fabrick, A., Sklarew, R., Wilson, J., "Point Source Model Evaluation and Development Study," Science Applications Incorporated, Westlake Village, California, March 1977.

5. Fabrick, A., Sklarew, R., Taft, J., Wilson, J., "Point Source Model Evaluation and Development Study - Appendix C, User Guide to IMPACT," Science Applications Incorporated, March 1977.

6. Skelton, E. P., and Kalvelage, S. C., "Methodology for Estimating Emissions for the Air Quality Maintenance Plan," Sacramento County Air Pollution Control District, November 1977.

7. "1976 Emissions Inventory for the Sacramento Metropolitan AQMP Modeling Study Area," Sacramento Regional Area Planning Commission, June 30, 1978, et seq. See Appendix A.

8. Dowling, R., "A Transportation Planners Handbook for the Sacramento Region," City of Sacramento, California, October 1977.

9. Kassel, S. J., and Winter, W. A., "Automated Methods of Acquiring and Reducing Aerometric Data," California Transportation Laboratory, Sacramento, California, March 1976.

10. "Air Quality Data Handling System Users Manual," U.S. Environmental Protection Agency Manual #APTD-1086, November 1972.

11. Faulkinbury, J., and Benson, P., "User Manual Air Quality Data Handling System," California Department of Transportation, Office of Transportation Laboratory, November 1977.

12. "Establishing a Datum for Air Quality Modeling Studies," California Air Resources Board, MAQU.

13. "A Format for the Computer Storage of Area Source Emission Data," State of California, Air Resources Board, Emission Inventory Section, June 30, 1977.

14. Racin, J. A., and Ranzieri, A. J., "Transportation Systems and Regional Air Quality, an Approach and Computer Program for Windflow Field Analysis," California Department of Transportation, Office of Transportation Laboratory, May 1976.

15. Turner, D. B., "Atmospheric Dispersion Modeling, A Critical Review," Journal of the Air Pollution Control Association, Vol. 29, No. 5, pp. 502-519, May 1979.

16. Ranzieri, A. J., Allen, P. A., and Tilden, J. W. "Evaluation of a Regional Photochemical Model for the Sacramento Area," California Air Resources Board, Planning Division, August 1979.

17. Reynolds, S. D., et al, "Photochemical Modeling of Transportation Control Strategies -- Volume I. Model Development, Performance Evaluation, and Strategy Assessment," Systems Applications, Inc., San Rafael, California, March 1979, et seq. (FHWA report numbers to be assigned).

18. "The Areal Representativeness of Air Monitoring Stations--Fresno Study Phase I (oxidant)," California Air Resources Board, p. 31, March 1977.

19. MacCracken, M. C., and Sauter, G. D., eds., "Development of an Air Pollution Model for the San Francisco Bay Area," UCRL-51920, Vols. 1 & 2 Lawrence Livermore Laboratory, Livermore, California, October 1975.

20. Sklarew, R. C., et al, "Model of Advection, Diffusion and Chemistry of Air Pollution (MADCAP) Evaluated at San Diego Air Basin," Science Applications, Inc., May 1978.

APPENDIX A

PART 1: Reports Pertinent to the SAI Airshed Model With 15-Step Chemistry

Roth, P. M., Reynolds, S. D., Roberts, P. J. W., and Seinfeld, J. H. (1971), "Development of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants - Final Report," Report 71-SAI-21. Systems Applications, Incorporated, San Rafael, California.

Reynolds, S. D., Seinfeld, J. H., and Roth, P. M., (1973), "Mathematical Modeling of Photochemical Air Pollution. I. Formulation of the Model," Atmospheric Environment, Vol. 7, p. 1033.

Roth, P. M., Roberts, P. J. W., Liu, M. K., Reynolds, S. D., and Seinfeld, J. H., (1974), "Mathematical Modeling of Photochemical Air Pollution. II. A Model and Inventory of Pollutant Emissions," Atmospheric Environment, Vol. 8, p. 97.

Reynolds, S. D., Liu, M. K., Hecht, T. A., Roth, P. M., and Seinfeld, J. H., (1974), "Mathematical Modeling of Photochemical Air Pollution. III. Evaluation of the Model", Atmospheric Environment, Vol. 8, p. 563.

___________ (1973), "Further Development and Validation of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants - Final Report," Report R73-19, Systems Applications, Incorporated, San Rafael, California.

___________ (1973b), "User's Guide and Description of the Computer Programs," Volume II of "Further Development and Validation of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants," Report R73-18, Systems Applications, Incorporated, San Rafael, California.

Whitney, D. C. (1973), "User's Guide and Description of the Data Preparation Programs," Appendix to Volume II of "Further Development of a Simulation Model for Estimating Ground Level Concentrations of Photochemical Pollutants," Systems Applications, Incorporated, San Rafael, California.

Hecht, T. A., Roth, P. M., and Seinfeld, J. H. (1973), "Mathematical Simulation of Atmospheric Photochemical Reactions: Model Development, Validation, and Application," Report R73-20, Systems Applications Incorporated, San Rafael, California.

Liu, M. K., Whitney, D. C., Reynolds, S. D., and Roth, P. M. (1973), "Automation of Meteorological and Air Quality Data for the SAI Urban Airshed Model," Report 73-SAI-32, Systems Applications, Incorporated, San Rafael, California,

PART 2: SRAPC Reports Pertinent to the Sacramento Modeling

"Future Strategies for Sacramento Regional Environmental Planning, 2nd Draft," Sacramento Regional Area Planning Commission, May 8, 1978.

"Emission Reduction Documentation & Air Quality Analysis for the Sacramento Metropolitan Air Quality Maintenance Area," Sacramento Regional Area Planning Commission, June 30, 1978.

"Modeling Techniques Used in the Sacramento Metropolitan Air Quality Maintenance Planning Program," Sacramento Regional Area Planning Commission, June 30, 1978.

"1976 Emissions Inventory for the Sacramento Metropolitan AQMP Modeling Study Area," Sacramento Regional Area Planning Commission, June 30, 1978.

"Summary, Draft Air Quality Plan," Sacramento Regional Area Planning Commission, October 1978.

"Draft Air Quality Plan," Sacramento Regional Area Planning Commission, October 1978.

"Regional Transportation Plan," Sacramento Regional Area Planning Commission, June 1978.

APPENDIX B

The ozone pollutant levels in the six tables in Appendix B represent hourly averaged readings, for the hours shown, from the monitoring sites in the case of the observed concentrations; and hourly averaged computer simulation predictions from the grid cells representing the monitoring sites in the case of the SMOG model simulation runs.

Meadowview Station
August 24, 1976

Hourly Averaged Ozone Concentrations at Times Shown (PPM)

	8-9	11-12	14-15	17-18
Observed	.03	.08	.08	.04
"Full Hydrocarbon" level run	.05	.07	.10	.06
"Two-thirds Hydrocarbon" level run	.05	.07	.10	.06
"One-third Hydrocarbon" level run	.03	.06	.10	.06
No boundary run	.05	.11	-	-
Zero emissions run	.05	.07	.10	-
"Clean Air Start" run	.03	.05	.03	.02

Northgate Station
August 24, 1976

Hourly Averaged Ozone Concentrations at Times Shown (PPM)

	8-9	11-12	14-15	17-18
Observed	.03	.08	.09	.04
"Full Hydrocarbon" level run	.06	.12	.10	.06
"Two-thirds Hydrocarbon" level run	.05	.09	.10	.06
"One-third Hydrocarbon" level run	.04	.06	.10	.06
No boundary run	.06	.12	-	-
Zero emissions level run	.06	.11	.11	-
"Clean Air Start" run	.03	.04	.04	.02

Roseville Station
August 24, 1976

Hourly Averaged Ozone Concentrations at Times Shown (PPM)

	8-9	11-12	14-15	17-18
Observed	.02	.06	.10	.05
"Full Hydrocarbon" level run	.07	.09	.10	.06
"Two-thirds Hydrocarbon" level run	.06	.09	.10	.06
"One-third Hydrocarbon" level run	.04	.09	.10	.06
No boundary run	.07	.17	-	-
Zero emissions level run	.07	.09	.10	-
"Clean Air Start" run	.03	.05	.03	.01

Sacramento Downtown ARB Station
August 24, 1976

Hourly Averaged Ozone Concentrations at Times Shown (PPM)

	8-9	11-12	14-15	17-18
Observed	.05	.13	.12	.06
"Full Hydrocarbon" level run	.05	.11	.10	.06
"Two-thirds Hydrocarbon" level run	.03	.08	.10	.06
"One-third Hydrocarbon" level run	.03	.05	.10	.06
No boundary run	.05	.11	-	-
Zero emissions run	.05	.11	.10	-
"Clean Air Start" run	.02	.04	.03	.02

Creekside Station
August 24, 1976

Hourly Averaged Ozone Concentrations at Times Shown (PPM)

	8-9	11-12	14-15	17-18
Observed	.04	.09	.11	.05
"Full Hydrocarbon" level run	.05	.10	.10	.07
"Two-thirds Hydrocarbon" level run	.05	.08	.10	.07
"One-third Hydrocarbon" level run	.04	.05	.10	.07
No boundary run	.05	.10	-	-
Zero emissions run	.05	.11	.10	-
"Clean Air Start" run	.03	.04	.05	.02

Rancho Seco Station
August 24, 1976

Hourly Averaged Ozone Concentrations at Times Shown (PPM)

	8-9	11-12	14-15	17-18
Observed	.01	.05	.06	.06
"Full Hydrocarbon" level run	.03	.08	.10	.07
"Two-thirds Hydrocarbon" level run	.03	.08	.10	.07
"One-third Hydrocarbon" level run	.03	.08	.10	.07
No boundary run	.03	.08	-	-
Zero emissions run	.03	.08	.10	-
"Clean Air Start" run	.03	.06	.04	.03

APPENDIX C

Computer printouts, accompanying this report to the Federal Highway Administration research office, as Appendix C, are a complete record of the aerometric data base gathered during the Sacramento portion of this research project. The printouts are in Air Quality Data Handling System format, See References Nos. 10 and 11.

A magnetic tape record of the data base has been forwarded with this report to the Federal Highway Administration research office in Washington, D.C.

Also accompanying this report to the Federal Highway Administration research office is a computer printout and a magnetic tape record of the aerometric data base gathered in the Bakersfield, California, region during the summers of 1977 and 1978.

Completing Appendix C are the input data for the SMOG model "two-thirds hydrocarbons" level run for the candidate day August 24, 1976.

```
++WRITE PRINT,TMENVSAC23
*         DATA SET TMENVSAC23 AT LEVEL 024 AS OF 08/06/79
 SACTO AUGUST 24 TH. 1976  FULLDATA BUT 2/3 RHC LEVEL
 &GRIDIT DX=2000,DY=2000,DZ=200,NX=25,NY=25,NZ=5 &END
 &OPTION IDOWND=1,IDOCEM=15,IDOPLM=0,IDODIF=1,IDOBAK=-3 &END
 &OPT ITEST=0,ISTART=0,IWINDS=1,ICONC=1,IAREA=1 &END
 &OUTPUT NUMHRS=13,IDOPLT=0,IDOPRN=1,IDOCAL=0,HRSAVG=1,IDOSUR=0
         NOWTIM=6 &END
   01   01    5.    5.    5.    0.    0.    0.    0.    0.   10.   10.
   11   01   10.   10.   15.   15.   15.   20.   20.   25.   30.   30.
   21   01   35.   40.   50.   60.   65.
   01   02    5.    5.    5.    5.    0.    0.    0.    0.    5.    5.
   11   02   10.   10.   10.   15.   15.   15.   20.   25.   25.   30.
   21   02   30.   30.   40.   50.   60.
   01   03    5.    5.    5.    0.    0.    0.    0.    0.    5.    5.
   11   03   10.   10.   10.   15.   15.   20.   20.   20.   25.   30.
   21   03   30.   40.   50.   65.   65.
   01   04    5.    5.    5.    0.    0.    0.    0.    0.    5.   10.
   11   04   10.   10.   15.   15.   20.   20.   25.   25.   30.   30.
   21   04   30.   40.   50.   65.   65.
   01   05    5.    5.    5.    5.    0.    0.    0.    0.    5.   10.
   11   05   10.   10.   15.   15.   20.   20.   25.   25.   30.   30.
   21   05   30.   50.   60.   65.   65.
   01   06    5.    5.    5.    5.    0.    0.    0.    0.    5.   10.
   11   06   10.   10.   15.   20.   20.   25.   25.   25.   25.   30.
   21   06   30.   40.   60.   65.   70.
   01   07    5.    5.    0.    0.    0.    0.    0.    0.    5.   10.
   11   07   10.   10.   15.   20.   20.   25.   25.   30.   30.   30.
   21   07   30.   40.   45.   60.   65.
   01   08    5.    5.    5.    0.    0.    0.    5.    5.   10.   10.
   11   08   15.   15.   20.   20.   25.   25.   30.   30.   30.   30.
   21   08   30.   40.   50.   55.   60.
   01   09    5.    5.    5.    5.   10.    5.    5.   10.   10.   10.
   11   09   15.   15.   20.   20.   20.   25.   30.   30.   35.   40.
   21   09   45.   45.   50.   55.   55.
   01   10    5.    5.    5.    5.   10.    5.    5.    5.   10.   10.
   11   10   10.   15.   15.   20.   20.   25.   30.   35.   40.   35.
   21   10   35.   50.   70.   90.   90.
   01   11   10.   10.   10.    5.    5.    5.    5.    5.   10.   10.
   11   11   15.   15.   20.   20.   25.   25.   30.   35.   40.   50.
   21   11   60.   65.   70.   80.   90.
   01   12    5.    5.    5.    5.    5.    5.    5.    5.   10.   10.
   11   12   10.   15.   15.   20.   20.   25.   30.   40.   50.   55.
   21   12   60.   70.   80.   90.   90.
   01   13   10.   10.   10.    5.    5.    5.    5.    5.    5.   10.
   11   13   10.   15.   15.   20.   25.   30.   30.   40.   50.   60.
   21   13   65.   70.   80.   85.   90.
   01   14   10.   10.   10.   10.   10.   10.   10.   10.   15.   15.
   11   14   15.   20.   20.   25.   25.   25.   30.   30.   40.   50.
   21   14   60.   70.   80.   90.   95.
   01   15   10.   10.   10.   10.   10.   10.   10.   10.   15.   15.
   11   15   20.   20.   25.   25.   25.   25.   30.   30.   40.   50.
   21   15   60.   80.   90.  100.  120.
   01   16    5.    5.    5.   10.   10.   10.   10.   10.   15.   20.
   11   16   20.   25.   25.   30.   30.   35.   40.   50.   60.   60.
   21   16   70.   90.  100.  110.  120.
   01   17    5.    5.    5.    5.    5.    5.    5.   10.   10.   10.
```

```
11    17  15.  15.  25.  30.  30.  30.  30.  35.  35.  50.
21    17  90. 120. 160. 180. 200.
01    18   5.   5.   5.   5.   5.   5.  10.  10.  10.  10.
11    18  15.  15.  20.  25.  30.  40.  50.  60.  65.  70.
21    18  80.  90. 120. 140. 160.
01    19   5.   5.   5.   5.   5.   5.  10.  10.  15.  15.
11    19  15.  20.  25.  25.  30.  40.  50.  60.  70.  80.
21    19 100. 130. 160. 200. 230.
01    20   5.   5.   5.  10.  10.  10.  10.  10.  15.  15.
11    20  20.  25.  30.  30.  35.  35.  30.  30.  40.  50.
21    20  60.  70. 130. 130. 130.
01    21   5.   5.   5.   5.  10.  10.  10.  10.  15.  15.
11    21  20.  25.  30.  35.  35.  35.  40.  50.  60.  80.
21    21  90. 130. 130. 130. 130.
01    22   5.   5.   5.   5.   5.  10.  10.  10.  15.  15.
11    22  20.  25.  30.  35.  35.  40.  45.  50.  60.  75.
21    22  90. 130. 130. 130. 130.
01    23   5.   5.   5.   5.  10.  10.  10.  10.  15.  20.
11    23  20.  25.  30.  35.  40.  45.  50.  60.  70.  80.
21    23  90. 120. 130. 130. 130.
01    24   5.   5.   5.   5.   5.   5.  10.  10.  10.  15.
11    24  20.  25.  30.  35.  35.  40.  50.  60.  80.  90.
21    24 120. 150. 135. 130. 130.
01    25  10.  10.  10.  10.  10.  10.  15.  20.  20.  20.
11    25  25.  25.  30.  35.  35.  40.  50.  60.  75.  90.
21    25 100. 120. 140. 130. 130.
-1
 1           SURFACE ROUGHNESS
 1     1 .74  .74  .74  .74  .74  .74  .74  .74  .74  .74
11     1 .74  .74  .74  .74  .74  .007 .007 .007 .007 .007
21     1 .007 .007 .007 .007 .007
 1     2 .74  .74  .74  .74  .74  .74  .74  .74  .74  .74
11     2 .74  .74  .74  .74  .007 .007 .007 .007 .007 .007
21     2 .007 .007 .007 .007 .007
 1     3 .74  .74  .74  .74  .74  .74  .74  .74  .74  .74
11     3 .74  .74  .007 .007 .007 .007 .007 .007 .007 .007
21     3 .007 .007 .007 .007 .007
 1     4 .74  .74  .74  .74  .74  .74  .74  .74  .74  .74
11     4 .74  .74  .74 1.08  .007 .007 .007 .007 .007 .007
21     4 .007 .007 .007 .007 .007
 1     5 .007 .007 .007 .007 .007 .74  .74  .74  .74  .74
11     5 .74  .74 1.08  .007 .007 .007 .007 .007 .007 .007
21     5 .007 .007 .007 .007 .007
 1     6 .74  .74  .74  .74  .74  .74  .74  .74  .74  .74
11     6 .007 .007 .007 .007 .007 .007 .007 .007 .007 .007
21     6 .007 .007 .007 .007 .007
 1     7 .74  .74  .74  .74  .74  .74  .74  .74  .74  .74
11     71.08  .74  .74  .007 .0071.98 1.98 1.98  .007 .007
21     7 .007 .007 .007 .007 .007
 1     8 .74  .74  .74  .74  .74  .74  .74 1.08 1.08 1.08
11     81.08 1.08 1.08 1.08  .0071.98 1.98 1.98  .007 .007
21     8 .007 .007 .007 .007 .007
 1     9 .74  .74  .74  .74  .74 1.08 1.08 1.08 1.08 1.08
11     91.08 1.08 1.08 1.98  .007 .007 .007 .007 .007 .007
21     9 .007 .007 .007 .007 .007
 1    10 .74  .74  .74  .74  .74 1.08 1.08 1.08 1.08 1.08
11    101.08 1.08 1.08 1.98 1.98  .007 .007 .007 .007 .007
```

```
  21    10 .007 .007 .007 .007 .007
   1    11 .74  .74  .74  .74  .74 1.08 1.08 1.08 1.08 1.08
  11    111.08 1.08 1.08 1.98 1.98 1.98  .007 .007 .007 .007
  21    11 .007 .007 .007 .007 .007
   1    12 .74  .74  .74  .74 1.08  .74  .74 1.08 1.08 1.08
  11    121.08 1.08 1.08 1.08 1.98 1.08 1.75 1.08  .007 .007
  21    12 .007 .007 .007 .007 .007
   1    13 .74  .74  .74  .74 1.08 1.08 1.08 1.08 1.08 1.08
  11    131.08 1.08 1.08 1.08 1.08 1.08 1.08  .114 .114 .114
  21    13 .007 .007 .007 .007 .007
   1    14 .74  .74  .74  .74  .74 1.08 1.08 1.08 1.08 1.08
  11    141.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08  .114 .114
  21    14 .114 .114 .007 .007 .007
   1    15 .74  .74  .74  .74 1.08 1.08 1.08 1.08 1.08 1.08
  11    151.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08  .114 .114
  21    15 .007 .007 .007 .007 .007
   1    16 .74  .74  .74  .74  .74  .74  .74  .74 1.08 1.08
  11    161.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08  .114 .114
  21    16 .114 .007 .007 .007 .007
   1    17 .74  .74  .74  .74  .74  .74 1.08 1.08 1.08 1.08
  11    171.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08  .114
  21    17 .114 .114 .114 .114 .114
   1    18 .74  .74  .74  .74  .74  .74  .74 1.08 1.08 1.08
  11    181.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08
  21    18 .114 .114 .114 .114 .114
   1    19 .74  .74  .74  .74  .74  .74  .74  .74 1.08 1.08
  11    191.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08
  21    191.08 1.08  .114 .114 .114
   1    20 .74  .74  .74  .74  .74  .74  .74  .74 1.08 1.08
  11    201.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08 1.08
  21    201.08 1.08 1.08 1.08 1.08
   1    21 .74  .74  .74  .74  .74  .74  .74  .74 1.08 1.08
  11    211.98 1.98  .74  .74 1.98 1.08 1.08 1.08 1.08 1.08
  21    211.08 1.08  .001 .001 .001
   1    22 .74  .74  .74  .74  .114 .114 .114 .114 .114 .114
  11    221.98 1.98 1.98 1.98 1.98 1.08 1.08 1.08 1.08 1.08
  21    221.08  .001 .001 .001 .001
   1    23 .74  .74  .74  .114 .114 .114 .114 .114 .114 .114
  11    23 .114 .114 .114 .114 .114 .1141.08 1.08 1.08 1.08
  21    231.08 1.08  .007 .001 .007
   1    24 .74  .74  .74  .74  .74  .114 .114 .114 .114 .114
  11    24 .114 .114 .114 .114 .114 .114 .1141.08 1.08 1.08
  21    241.08 1.08  .007 .001 .007
   1    25 .74  .74  .74  .74  .114 .114 .114 .114 .114 .114
  11    25 .114 .114 .114 .114 .114 .114 .1141.08 1.08 1.98
  21    251.98 1.98 1.08  .001 .001
  -1
  11    07          WIND AT HR 0600
  16    18 1.0      DEL CAMPO
  .9   150
  10    19 1.0      RIO LINDA
 3.1   150
  18    24 1.0      ROSEVILLE
 1.3   180
   9     8 1.0      MEADOWVIEW
 1.8   150
  11    12 1.0      TRANS LAB
```

```
   .9  150
   18    3 1.0     WILTON
  2.2  150
   25   10 1.0     RANCHO CORDOVA
  1.8  150
   25    1 1.0     RANCHO SECO
   .4  162
    2   12 1.0     CAUSEWAY
  1.8  120
    4   10 1.0     SHIP CHANNEL
  1.3  160
    5   14 1.0     ACADEMY
  1.3  140
    3   07         STABILITY AT HOUR 0600
    2   12
    6    6    4    4    4
   11   12
    6    6    4    4    4
   25   10
    6    6    4    4    4
    0   24        POINT SOURCE INPUT
    1   07         AREA SOURCE INPUT
    3   24      BACKGROUND CONCENTRATIONS
  .02  .07  .01 .020 .017 .072 .003    0    0  .02    0    0    0    0
 .006 .001  .05 .014 .011 .050 .002    0    0  .02    0    0    0    0
 .006 .001  .05 .014 .011 .050 .002    0    0  .02    0    0    0    0
 .001 .001  .01 .014 .011 .050 .002    0    0  .02    0    0    0    0
 .001 .001  .01 .014 .011 .050 .002    0    0  .02    0    0    0    0
  .03  .06  .01 .016 .013 .060 .002    0    0  .02    0    0    0    0
 .006 .001  .05 .011 .009 .040 .002    0    0  .02    0    0    0    0
 .006 .001  .05 .011 .009 .040 .002    0    0  .02    0    0    0    0
 .001 .001  .01 .011 .009 .040 .002    0    0  .02    0    0    0    0
 .001 .001  .01 .011 .009 .040 .002    0    0  .02    0    0    0    0
  .04  .08  .01 .010 .009 .040 .002    0    0  .02    0    0    0    0
 .006 .001  .05 .007 .007 .025 .001    0    0  .02    0    0    0    0
 .006 .001  .05 .007 .007 .025 .001    0    0  .02    0    0    0    0
 .001 .001  .01 .007 .007 .025 .001    0    0  .02    0    0    0    0
 .001 .001  .01 .007 .007 .025 .001    0    0  .02    0    0    0    0
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2
```

```
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2
        7            BOUNDARY CONCENTRATIONS
  .03  .08  .01 .013 .011 .046 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
  .03  .06  .01 .013 .011 .046 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
  .05  .09  .01 .013 .011 .046 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
  .03  .06  .01 .013 .010 .046 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .006 .001  .05 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .010 .007 .030 .002    0    0  .01    0    0    0    0
 .001 .001  .01 .007 .006 .026 .001    0    0  .01    0    0    0    0
  18. 34.0   1.  2.017000     GLOBALS FOR HOUR 0600-0700
   11   08            WIND FIELD AT HR 0700
   16   18 1.0        DEL CAMPO
   .9  120
   10   19 1.0        RIO LINDA
  2.2  130
   18   24 1.0        ROSEVILLE
  1.3  150
    9    8 1.0        MEADOWVIEW
  1.3  180
   11   12 1.0        TRANS LAB
  1.3  120
   18    3 1.0        WILTON
  1.8  150
   25   10 1.0        RANCHO CORDOVA
  1.3  150
   25    1 1.0        RANCHO SECO
  0.0  162
    2   12 1.0        CAUSEWAY
  1.3  120
    4   10 1.0        SHIP CHANNEL
  1.3  160
    5   14 1.0        ACADEMY
  1.3  115
    3    8            STABILITY AT HOUR 0700
    2   12
    6    6    4    4    4
   11   12
    6    6    4    4    4
```

```
   25   10
    6    6    4    4    4
    1    8         AREA SOURCE INPUT
         8         BOUNDARY CONCENTRATIONS
 .03  .070 .010 .01  .01  .045 .008   0    0   .01   0    0    0    0
 .045 .015 .025 .01  .01  .04  .008   0    0   .01   0    0    0    0
 .02  .030 .040 .01  .01  .04  .008   0    0   .01   0    0    0    0
 .015 .005 .023 .01  .01  .04  .008   0    0   .01   0    0    0    0
 .014 .005 .020 .01  .01  .04  .008   0    0   .01   0    0    0    0
 .03  .060 .010 .01  .008 .03  .005   0    0   .01   0    0    0    0
 .02  .005 .035 .005 .006 .025 .005   0    0   .01   0    0    0    0
 .02  .035 .045 .005 .006 .02  .005   0    0   .01   0    0    0    0
 .013 .005 .015 .005 .005 .02  .005   0    0   .01   0    0    0    0
 .012 .005 .015 .005 .005 .02  .005   0    0   .01   0    0    0    0
 .040 .070 .010 .008 .007 .03  .005   0    0   .01   0    0    0    0
 .04  .012 .030 .008 .007 .03  .005   0    0   .01   0    0    0    0
 .02  .035 .040 .005 .005 .025 .005   0    0   .01   0    0    0    0
 .014 .005 .020 .005 .005 .024 .005   0    0   .01   0    0    0    0
 .013 .005 .018 .005 .005 .024 .005   0    0   .01   0    0    0    0
 .030 .050 .014 .01  .01  .04  .005   0    0   .01   0    0    0    0
 .05  .015 .025 .01  .01  .04  .005   0    0   .01   0    0    0    0
 .02  .035 .045 .01  .01  .04  .005   0    0   .01   0    0    0    0
 .015 .005 .02  .01  .01  .04  .005   0    0   .01   0    0    0    0
 .014 .005 .015 .01  .01  .04  .005   0    0   .01   0    0    0    0
 .013 .005 .015 .005 .005 .02  .005   0    0   .01   0    0    0    0
  20.  88.0  1.  2.017000   GLOBALS FOR HOUR 0700-0800
   11    9         WIND DATA AT HOUR 0800
   16   18 1.0     DEL CAMPO
  1.3  140
   10   19 1.0     RIO LINDA
  2.7  120
   18   24 1.0     ROSEVILLE
  1.8  150
    9    8 1.0     MEADOWVIEW
  1.3  150
   11   12 1.0     TRABS LAB
  1.3   90
   18    3 1.0     WILTON
  1.3  120
   25   10 1.0     RANCHO CORDOVA
  1.3  170
   25    1 1.0     RANCHO SECO
   .4  280
    2   12 1.0     CAUSEWAY
   .9  100
    4   10 1.0     SHIP CHANNEL
  1.3  170
    5   14 1.0     ACADEMY
  1.3   90
    3    9         STABILITY AT HOUR 0800
    2   12
    2    2    6    4    4
   11   12
    2    2    6    4    4
   25   10
    2    2    6    4    4
    1    9         AREA SOURCE INPUT
```

```
        9           BOUNDARY CONCENTRATIONS
 .04   .04  .01  .01  .01  .05  .01     0    0  .01    0    0    0    0
 .04   .02  .03  .01  .01  .05  .01     0    0  .01    0    0    0    0
 .02   .005 .05  .005 .01  .045 .01     0    0  .01    0    0    0    0
 .015  .005 .04  .005 .01  .04  .01     0    0  .01    0    0    0    0
 .015  .005 .045 .005 .01  .04  .01     0    0  .01    0    0    0    0
 .03   .04  .01  .005 .005 .03  .005    0    0  .01    0    0    0    0
 .03   .015 .03  .005 .005 .02  .005    0    0  .01    0    0    0    0
 .02   .005 .05  .005 .005 .02  .005    0    0  .01    0    0    0    0
 .015  .005 .035 .005 .005 .02  .005    0    0  .01    0    0    0    0
 .015  .005 .03  .005 .005 .02  .005    0    0  .01    0    0    0    0
 .04   .03  .01  .005 .005 .03  .005    0    0  .01    0    0    0    0
 .04   .015 .03  .005 .005 .03  .005    0    0  .01    0    0    0    0
 .015  .005 .05  .005 .005 .02  .005    0    0  .01    0    0    0    0
 .015  .005 .03  .005 .005 .02  .005    0    0  .01    0    0    0    0
 .015  .005 .03  .005 .005 .02  .005    0    0  .01    0    0    0    0
 .03   .030 .015 .01  .01  .05  .01     0    0  .01    0    0    0    0
 .05   .024 .03  .01  .01  .05  .01     0    0  .01    0    0    0    0
 .02   .004 .06  .005 .01  .04  .01     0    0  .01    0    0    0    0
 .015  .004 .06  .005 .005 .04  .01     0    0  .01    0    0    0    0
 .015  .004 .06  .005 .005 .04  .01     0    0  .01    0    0    0    0
 .01   .005 .04  .005 .005 .02  .005    0    0  .01    0    0    0    0
  23.130.0   1.  1.517000     GLOBALS FOR HOUR 0800-0900
   11    10           WIND DATA AT HR 0900
   16    18 1.0       DEL CAMPO
  1.3   180
   10    19 1.0       RIO LINDA
  2.7   120
   18    24 1.0       ROSEVILLE
  1.3   210
    9     8 1.0       MEADOWVIEW
  1.8   180
   11    12 1.0       TRANS LAB
  1.3   120
   18     3 1.0       WILTON
  1.8    90
   25    10 1.0       RANCHO CORDOVA
  1.3   180
   25     1 1.0       RANCHO SECO
   .9   270
    2    12 1.0       CAUSEWAY
   .9   120
    4    10 1.0       SHIP CHANNEL
  1.3   140
    5    14 1.0       ACADEMY
  1.3    90
    3    10           STABILITY AT HOUR 0900
    2    12
    2     2    6    4    4
   11    12
    2     2    6    4    4
   25    10
    2     2    6    4    4
    1    10           AREA SOURCE INPUT
         10           BOUNDARY CONCENTRATIONS
 .04   .030 .02  .008 .01  .05  .016    0    0  .01    0    0    0    0
 .04   .015 .05  .006 .01  .05  .016    0    0  .01    0    0    0    0
```

```
 .03   .01  .05  .006 .01  .05  .016   0   0  .01   0   0   0   0
 .01   .003 .06  .004 .008 .035 .016   0   0  .01   0   0   0   0
 .01   .003 .06  .004 .008 .035 .016   0   0  .01   0   0   0   0
.04    .030 .02  .005 .005 .02  .008   0   0  .01   0   0   0   0
 .03   .015 .03  .005 .005 .02  .008   0   0  .01   0   0   0   0
 .03   .01  .04  .005 .005 .02  .008   0   0  .01   0   0   0   0
 .01   .004 .035 .002 .003 .015 .008   0   0  .01   0   0   0   0
 .01   .004 .035 .002 .003 .015 .008   0   0  .01   0   0   0   0
.04    .030 .020 .008 .006 .025 .009   0   0  .01   0   0   0   0
 .03   .015 .04  .004 .006 .025 .009   0   0  .01   0   0   0   0
 .02   .01  .05  .004 .006 .025 .009   0   0  .01   0   0   0   0
 .01   .004 .045 .002 .004 .02  .009   0   0  .01   0   0   0   0
 .01   .004 .045 .002 .004 .02  .009   0   0  .01   0   0   0   0
.030   .03  .020 .005 .01  .04  .01    0   0  .01   0   0   0   0
 .04   .014 .055 .005 .01  .04  .01    0   0  .01   0   0   0   0
 .03   .01  .07  .005 .01  .04  .01    0   0  .01   0   0   0   0
 .014  .035 .07  .004 .008 .035 .01    0   0  .01   0   0   0   0
 .013  .033 .07  .004 .008 .035 .01    0   0  .01   0   0   0   0
.01    .004 .05  .004 .008 .02  .01    0   0  .01   0   0   0   0
  26.155.0    1.   1.517000     GLOBALS FOR HOUR 0900-1000
   11    11             WIND DATA AT HOUR 1000
   16    18 1.0         DEL CAMPO
  1.3   240
   10    19 1.0         RIO LINDA
  2.2   130
   18    24 1.0         ROSEVILLE
  1.8   270
    9     8 1.0         MEADOWVIEW
   .9   300
   11    12 1.0         TRANS LAB
  1.3   180
   18     3 1.0         WILTON
  1.8    80
   25    10 1.0         RANCHO CORDOVA
  1.8   210
   25     1 1.0         RANCHO SECO
   .9   300
    2    12 1.0         CAUSEWAY
   .9   150
    4    10 1.0         SHIP CHANNEL
   .9   150
    5    14 1.0         ACADEMY
  1.3   200
    3    11             STABILITY AT HOUR 1000
    2    12
    2     2    6    4    4
   11    12
    2     2    6    4    4
   25    10
    2     2    6    4    4
    1    11             AREA SOURCE INPUT
         11             BOUNDARY CONCENTRATIONS
.04    .02  .04  .005 .01  .045 .02    0   0  .01   0   0   0   0
 .03   .01  .04  .005 .01  .045 .02    0   0  .01   0   0   0   0
 .03   .01  .04  .005 .01  .045 .02    0   0  .01   0   0   0   0
 .013  .003 .04  .002 .007 .035 .015   0   0  .01   0   0   0   0
 .013  .003 .04  .002 .007 .035 .015   0   0  .01   0   0   0   0
```

```
 .03   .02  .04  .003 .005 .02  .01   0   0  .01   0   0   0   0
 .025  .01  .04  .003 .005 .02  .01   0   0  .01   0   0   0   0
 .025  .01  .04  .003 .005 .02  .01   0   0  .01   0   0   0   0
 .01   .004 .04  .001 .002 .015 .05   0   0  .01   0   0   0   0
 .01   .004 .04  .001 .002 .015 .05   0   0  .01   0   0   0   0
 .02   .02  .04  .003 .005 .025 .01   0   0  .01   0   0   0   0
 .03   .01  .05  .003 .005 .025 .01   0   0  .01   0   0   0   0
 .03   .01  .05  .003 .005 .025 .01   0   0  .01   0   0   0   0
 .01   .004 .05  .015 .003 .02  .05   0   0  .01   0   0   0   0
 .01   .004 .05  .015 .003 .02  .05   0   0  .01   0   0   0   0
 .030  .020 .04  .005 .01  .045 .02   0   0  .01   0   0   0   0
 .038  .01  .04  .005 .01  .045 .02   0   0  .01   0   0   0   0
 .033  .01  .04  .005 .01  .045 .02   0   0  .01   0   0   0   0
 .013  .003 .04  .002 .007 .035 .015  0   0  .01   0   0   0   0
 .012  .003 .04  .002 .007 .035 .015  0   0  .01   0   0   0   0
 .01   .003 .04  .002 .005 .025 .015  0   0  .01   0   0   0   0
   28.171.0    1.   1.017000     GLOBALS FOR HOUR 1000-1100
    11    12            WIND DATA AT HOUR 1100
    16    18 1.0        DEL CAMPO
   1.3   290
    10    19 1.0        RIO LINDA
    .9   150
    18    24 1.0        ROSEVILLE
   2.2    30
     9     8 1.0        MEADOWVIEW
   1.8   240
    11    12 1.0        TRANS LAB
   1.3   180
    18     3 1.0        WILTON
    .9   130
    25    10 1.0        RANCHO CORDOVA
   2.2   220
    25     1 1.0        RANCHO SECO
    .9   260
     2    12 1.0        CAUSEWAY
    .9   180
     4    10 1.0        SHIP CHANNEL
    .9   240
     5    14 1.0        ACADEMY
   1.8   250
     3    12            STABILITY AT HOUR 1100
     2    12
     2     2    6    4    4
    11    12
     2     2    6    4    4
    25    10
     2     2    6    4    4
     1    12            AREA SOURCE INPUT
          12            BOUNDARY CONCENTRATIONS
 .03   .010 .05  .003 .008 .04  .02   0   0  .01   0   0   0   0
 .03   .008 .05  .003 .008 .04  .02   0   0  .01   0   0   0   0
 .03   .008 .05  .003 .008 .04  .02   0   0  .01   0   0   0   0
 .01   .002 .05 .0015 .006 .03  .015  0   0  .01   0   0   0   0
 .01   .002 .05 .0015 .006 .03  .015  0   0  .01   0   0   0   0
 .030  .01  .06  .002 .004 .02  .01   0   0  .01   0   0   0   0
 .025  .01  .06  .002 .004 .02  .01   0   0  .01   0   0   0   0
 .025  .01  .06  .002 .004 .02  .01   0   0  .01   0   0   0   0
```

```
 .01   .003 .06 .0003 .002 .015 .007    0    0  .01    0    0    0    0
 .01   .003 .06 .0003 .002 .015 .007    0    0  .01    0    0    0    0
.020   .02  .06  .002 .005 .025 .01     0    0  .01    0    0    0    0
 .025 .01   .06  .002 .005 .025 .01     0    0  .01    0    0    0    0
 .025 .01   .06  .002 .005 .025 .01     0    0  .01    0    0    0    0
 .01   .003 .07  .001 .003 .02  .008    0    0  .01    0    0    0    0
 .01   .003 .05  .001 .003 .02  .008    0    0  .01    0    0    0    0
.020   .010 .06  .003 .008 .04  .02     0    0  .01    0    0    0    0
 .03   .005 .06  .003 .008 .04  .02     0    0  .01    0    0    0    0
 .03   .005 .06  .003 .008 .04  .02     0    0  .01    0    0    0    0
 .01 .0015 .06   .002 .006 .035 .015    0    0  .01    0    0    0    0
 .008.0015 .06   .002 .006 .035 .015    0    0  .01    0    0    0    0
.01    .002 .008 .001 .004 .03  .01     0    0  .01    0    0    0    0
  30.178.0    1.  1.017000     GLOBALS FOR HOUR 1100-1200
    11    13           WIND DATA AT HOUR 1200
    16    18 1.0       DEL CAMPO
   1.3   270
    10    19 1.0       RIO LINDA
   1.3   220
    18    24 1.0       ROSEVILLE
   1.8   320
     9     8 1.0       MEADOWVIEW
   2.2   240
    11    12 1.0       TRANS LAB
   1.3   240
    18     3 1.0       WILTON
    .9   150
    25    10 1.0       RANCHO CORDOVA
   2.2   240
    25     1 1.0       RANCHO SECO
    .9   290
     2    12 1.0       CAUSEWAY
   1.3   150
     4    10 1.0       SHIP CHANNEL
   1.3   270
     5    14 1.0       ACADEMY
   2.2   260
     3    13           STABILITY AT HOUR 1200
     2    12
     2     2    2    2    2
    11    12
     2     2    2    2    2
    25    10
     2     2    2    2    2
     1    13           AREA SOURCE INPUT
          13           BOUNDARY CONCENTRATIONS
.030   .010 .07  .002 .007 .04  .015    0    0  .01    0    0    0    0
 .025 .005  .07  .002 .007 .04  .015    0    0  .01    0    0    0    0
 .025 .005  .07  .002 .007 .04  .015    0    0  .01    0    0    0    0
 .008 .001  .07  .001 .005 .03  .015    0    0  .01    0    0    0    0
 .008 .001  .07  .001 .005 .03  .015    0    0  .01    0    0    0    0
.020   .010 .07  .001 .003 .02  .01     0    0  .01    0    0    0    0
 .015 .005  .08  .001 .003 .02  .01     0    0  .01    0    0    0    0
 .015 .005  .08  .001 .003 .02  .01     0    0  .01    0    0    0    0
 .015 .003  .06  .001 .003 .015 .08     0    0  .01    0    0    0    0
 .015 .003  .06  .001 .003 .015 .08     0    0  .01    0    0    0    0
.020   .010 .07  .002 .004 .025 .01     0    0  .01    0    0    0    0
```

```
 .02  .005 .08  .002 .004 .025 .01     0    0  .01    0    0    0    0
 .02  .005 .08  .002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .002 .07  .001 .003 .02  .01     0    0  .01    0    0    0    0
 .008 .002 .07  .001 .003 .02  .01     0    0  .01    0    0    0    0
.020  .010 .07  .002 .006 .04  .02     0    0  .01    0    0    0    0
 .025 .005 .07  .002 .006 .04  .02     0    0  .01    0    0    0    0
 .025 .005 .07  .002 .006 .04  .02     0    0  .01    0    0    0    0
 .01  .002 .07  .001 .005 .03  .015    0    0  .01    0    0    0    0
 .01  .002 .07  .001 .005 .03  .015    0    0  .01    0    0    0    0
.008  .002 .07  .001 .004 .02  .01     0    0  .01    0    0    0    0
  31.179.0   1.  1.017000    GLOBALS FOR HOUR 1200-1300
   11   14          WIND DATA AT HOUR 1300
   16   18 1.0      DEL CAMPO
  1.8  270
   10   19 1.0      RIO LINDA
  1.8  210
   18   24 1.0      ROSEVILLE
  2.2  240
    9    8 1.0      MEADOWVIEW
  2.2  270
   11   12 1.0      TRANS LAB
  1.8  240
   18    3 1.0      WILTON
  1.8  210
   25   10 1.0      RANCHO CORDOVA
  3.1  240
   25    1 1.0      RANCHO SECO
  1.3  290
    2   12 1.0      CAUSEWAY
  1.3  210
    4   10 1.0      SHIP CHANNEL
  1.8  270
    5   14 1.0      ACADEMY
  2.2  270
    3   14          STABILITY AT HOUR 1300
    2   12
    2    2    2    2    2
   11   12
    2    2    2    2    2
   25   10
    2    2    2    2    2
    1   14          AREA SOURCE INPUT
        14          BOUNDARY CONCENTRATIONS
.020  .002 .08 .0007 .005 .03  .015    0    0  .01    0    0    0    0
 .015 .002 .08 .0007 .005 .03  .015    0    0  .01    0    0    0    0
 .015 .002 .08 .0007 .005 .03  .015    0    0  .01    0    0    0    0
 .015 .002 .08 .0007 .005 .03  .015    0    0  .01    0    0    0    0
 .015 .002 .08 .0007 .005 .03  .015    0    0  .01    0    0    0    0
.020  .002 .09 .0007 .003 .015 .007    0    0  .01    0    0    0    0
 .015 .002 .06 .0007 .003 .015 .007    0    0  .01    0    0    0    0
 .015 .002 .06 .0007 .003 .015 .007    0    0  .01    0    0    0    0
 .015 .002 .06 .0007 .003 .015 .007    0    0  .01    0    0    0    0
 .015 .002 .06 .0007 .003 .015 .007    0    0  .01    0    0    0    0
.010  .002 .08 .0007 .004 .015 .01     0    0  .01    0    0    0    0
 .015 .002 .08 .0007 .004 .015 .01     0    0  .01    0    0    0    0
 .015 .002 .08 .0007 .004 .015 .01     0    0  .01    0    0    0    0
 .015 .002 .08 .0007 .004 .015 .01     0    0  .01    0    0    0    0
```

```
 .015 .002 .08 .0007 .004 .015 .01      0    0  .01    0    0    0    0
.020  .002 .09 .0007 .005 .035 .015     0    0  .01    0    0    0    0
 .015 .002 .10 .0007 .005 .035 .015     0    0  .01    0    0    0    0
 .015 .002 .10 .0007 .005 .035 .015     0    0  .01    0    0    0    0
 .015 .002 .10 .0007 .005 .035 .015     0    0  .01    0    0    0    0
 .015 .002 .10 .0007 .005 .035 .015     0    0  .01    0    0    0    0
.01   .002 .08 .0007 .004 .02  .01      0    0  .01    0    0    0    0
  33.173.0   1.  1.017000    GLOBALS FOR HOUR 1300-1400
    11   15          WIND DATA AT  HOUR  1400
    16   18 1.0      DEL CAMPO
   2.2  210
    10   19 1.0      RIO LINDA
   1.3  210
    18   24 1.0      ROSEVILLE
   2.2  260
     9    8 1.0      MEADOWVIEW
   2.7  240
    11   12 1.0      TRANS LAB
   1.8  210
    18    3 1.0      WILTON
   1.3  200
    25   10 1.0      RANCHO CORDOVA
   3.1  220
    25    1 1.0      RANCHO SECO
   1.3  280
     2   12 1.0      CAUSEWAY
   1.8  150
     4   10 1.0      SHIP CHANNEL
   1.8  240
     5   14 1.0      ACADEMY
   2.7  230
     3   15          STABILITY AT HOUR 1400
     2   12
     2    2    2    2    2
    11   12
     2    2    2    2    2
    25   10
     2    2    2    2    2
     1   15          AREA SOURCE INPUT
         15          BOUNDARY CONCENTRATIONS
 .01   .002 .09 .0004 .004 .03  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
 .01   .002 .09 .0004 .004 .015 .005    0    0  .01    0    0    0    0
  .01  .002 .08 .0004 .004 .015 .005    0    0  .01    0    0    0    0
  .01  .002 .08 .0004 .004 .015 .005    0    0  .01    0    0    0    0
  .01  .002 .08 .0004 .004 .015 .005    0    0  .01    0    0    0    0
  .01  .002 .08 .0004 .004 .015 .005    0    0  .01    0    0    0    0
 .01   .002 .09 .0004 .004 .02  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .02  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .02  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .02  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .02  .01     0    0  .01    0    0    0    0
 .01   .002 .09 .0004 .004 .03  .01     0    0  .01    0    0    0    0
  .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
```

```
 .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
 .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
 .01  .002 .10 .0004 .004 .03  .01     0    0  .01    0    0    0    0
.01   .002 .10 .0004 .004 .025 .01     0    0  .01    0    0    0    0
  33.161.0   1.  0.817000    GLOBALS FOR HOUR 1400-1500
   11   16           WIND DATA AT HOUR 1500
   16   18 1.0       DEL CAMPO
  2.2  260
   10   19 1.0       RIO LINDA
  1.3  170
   18   24 1.0       ROSEVILLE
  2.7  210
    9    8 1.0       MEADOWVIEW
  2.7  210
   11   12 1.0       TRANS LAB
  1.8  210
   18    3 1.0       WILTON
  1.3  170
   25   10 1.0       RANCHO CORDOVA
  3.6  240
   25    1 1.0       RANCHO SECO
  1.3  280
    2   12 1.0       CAUSEWAY
  2.2  160
    4   10 1.0       SHIP CHANNEL
  1.8  240
    5   14 1.0       ACADEMY
  2.2  230
    3   16           STABILITY AT HOUR 1500
    2   12
    2    2    2    4    4
   11   12
    2    2    2    4    4
   25   10
    2    2    2    4    4
    1   16           AREA SOURCE INPUT
        16           BOUNDARY CONCENTRATIONS
.010  .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
.010  .001 .08 .0002 .004 .015 .005    0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .015 .005    0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .015 .005    0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .015 .005    0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .015 .005    0    0  .01    0    0    0    0
.010  .001 .09 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
.010  .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
 .008 .001 .08 .0002 .004 .025 .01     0    0  .01    0    0    0    0
```

```
.008  .001 .08 .0002 .004 .02  .008    0    0  .01    0    0    0    0
  33.138.0   1.  0.517000    GLOBALS FOR HOUR 1500-1600
   11   17         WIND DATA AT HOUR 1600
   16   18 1.0     DEL CAMPO
  1.8  250
   10   19 1.0     RIO LINDA
  1.3  130
   18   24 1.0     ROSEVILLE
  1.8  200
    9    8 1.0     MEADOWVIEW
  2.7  210
   11   12 1.0     TRANS LAB
  2.2  210
   18    3 1.0     WILTON
  2.2  240
   25   10 1.0     RANCHO CORDOVA
  3.1  220
   25    1 1.0     RANCHO SECO
  1.8  290
    2   12 1.0     CAUSEWAY
  2.7  200
    4   10 1.0     SHIP CHANNEL
  2.2  240
    5   14 1.0     ACADEMY
  2.7  220
    3   17         STABILITY AT HOUR 1600
    2   12
    3    3    3    4    4
   11   12
    3    3    3    4    4
   25   10
    3    3    3    4    4
    1   17         AREA SOURCE INPUT
        17         BOUNDARY CONCENTRATIONS
 .008  .001 .07 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .07 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .07 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .07 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .07 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008  .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008  .001 .11 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008  .001 .08 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008 .001 .09 .0001 .003 .025 .008    0    0  .01    0    0    0    0
 .008  .001 .08 .0001 .003 .025 .008    0    0  .01    0    0    0    0
  34.101.0   1.  0.817000    GLOBALS FOR HOUR 1600-1700
   11   18         WIND DATA AT HOUR 1700
```

```
   16    18 1.0      DEL CAMPO
  2.2   210
   10    19 1.0      RIO LINDA
  2.2   130
   18    24 1.0      ROSEVILLE
  2.2   210
    9     8 1.0      MEADOWVIEW
  3.1   210
   11    12 1.0      TRANS LAB
  1.8   210
   18     3 1.0      WILTON
  1.8   240
   25    10 1.0      RANCHO CORDOVA
  4.0   210
   25     1 1.0      RANCHO SECO
  1.8   280
    2    12 1.0      CAUSEWAY
  4.5   210
    4    10 1.0      SHIP CHANNEL
  2.7   230
    5    14 1.0      ACADEMY
  4.5   220
    3    18          STABILITY AT HOUR 1700
    2    12
    4     4    4     4    4
   11    12
    3     3    4     4    4
   25    10
    3     3    4     4    4
    1    18          AREA SOURCE INPUT
         18          BOUNDARY CONCENTRATIONS
.020 .0005 .07 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
.020 .0005 .08 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
.020 .0005 .10 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
.020 .0005 .07 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
 .008.0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
.008 .0005 .06 .0001 .003 .025 .007   0   0  .01   0   0   0   0
  33. 48.0    1.  0.817000    GLOBALS FOR HOUR 1700-1800
   11    19          WIND DATA AT HOUR AT 1800
   16    18 1.0      DEL CAMPO
  2.7   210
   10    19 1.0      RIO LINDA
```